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Microwaves & RF

News
Analog circuit hikes PA efficiency

Design Feature
Meld load-pull tests with EDA tools

Product Technology
Capacitor supplier turns to TCXOs

On-Wafer Probes Test Si ICs To 110 GHz

Wireless Technology Issue

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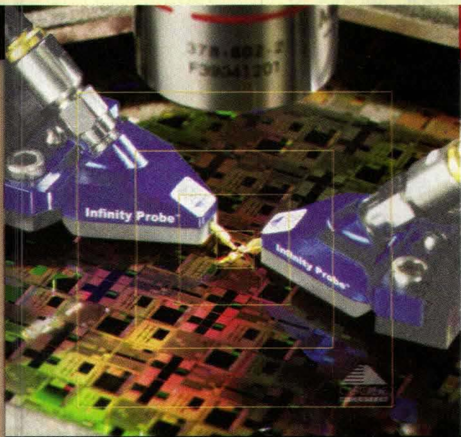

COVER STORY

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Design

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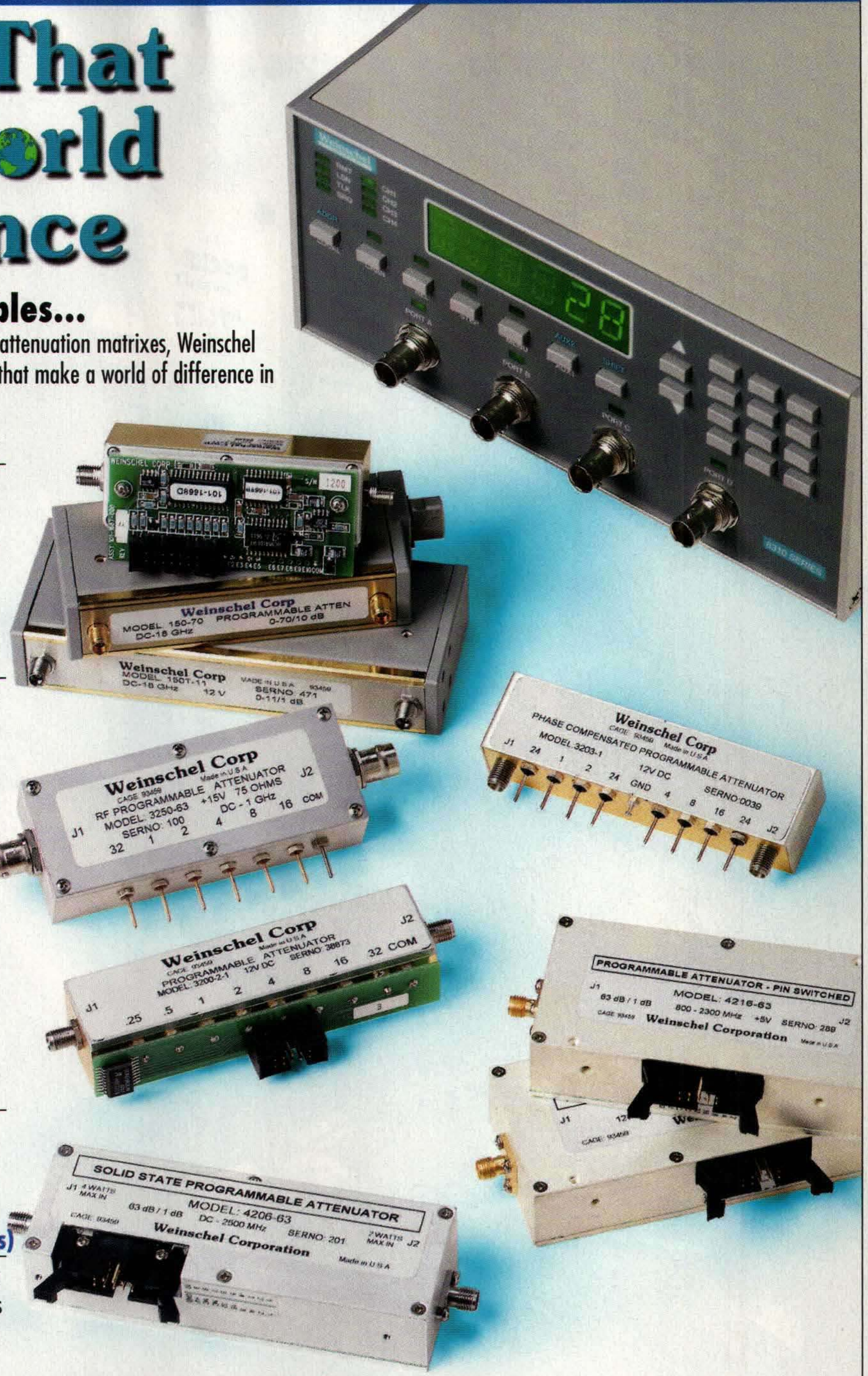
Products That Make a World of Difference



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- 3200 Series; Options for Frequencies to 3 GHz & higher
- Phase Compensated & 75 Ohm Designs
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Model No.	FREQ (GHz)	ATTN (dB)	Cells		
3200-1	dc-2.0	127/1	8	✚	◆
3200-2	dc-2.0	0.63.75/.25	8	✚	◆
3201-1	dc-2.0	31/1	5	✚	◆
3201-2	dc-2.0	120/10	5	✚	◆
3201-4	dc-2.0	1.2/1	5		
3205-1	dc-2.0	70/10	5	✚	◆
3205-2	dc-2.0	55/5	5	✚	◆
3205-3	dc-2.0	1.5/1	5	✚	◆
3206-1	dc-2.0	63/1	6	✚	◆
3209-1	dc-2.0	64.5/0.1	10	✚	
3250-63	dc-1.0	63/1	6	✷	
150-11	dc-18.0	11/1	4	✚	➤
150-15	dc-18.0	15/1	4	✚	➤
150-31	dc-18.0	0-31/1	5	✚	➤
150-62	dc-18.0	62/2	5	✚	➤
150-70	dc-18.0	70/10	3	✚	➤
150-75	dc-18.0	75/5	4	✚	➤
150-110	dc-18.0	110/10	4	✚	➤
152-55	dc-26.5	55/5	4	✚	
152-90	dc-26.5	90/10	4	✚	

✚ Available with SmartStep™ Control Circuitry

➤ Optional frequency ranges available, use 151 for dc-4.0 & 152 for dc-26.5 GHz

◆ 3 GHz Designs Available, ✷ 75 Ohm Model

Attenuator Units (8310, 8311 & 8312 Series)

- Provides a flexible, easy to program, low cost solution for bench test/calibration setups and subsystem applications
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- Relative vs. Nominal attenuation step function
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  - RS-232, RS-422, RS-485

New Solid-State Switched (4200 Series)

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- High IP3 & Higher Power Designs
- Special Configurations Available!

Model No.	FREQ (GHz)	ATTN (dB)	Cells
4206-63	0.01-2.5	63/1	6
4208-63.75	0.01-2.5	63.75/.25	8
4216-63	0.8-2.3	63/1	6
4218-63.75	0.8-2.3	0.63.75/.25	8
4218-127	0.8-2.3	127/1	8
4226-63	0.8-3.0	63/1	6
4228-63.75	0.8-2.5	0.63.75/.25	8
4238-103	0.8-3.0	103/1	8
4238-63.75	0.01-2.5	0.63.75/.25	8
4238-103	0.01-2.5	103/1	8

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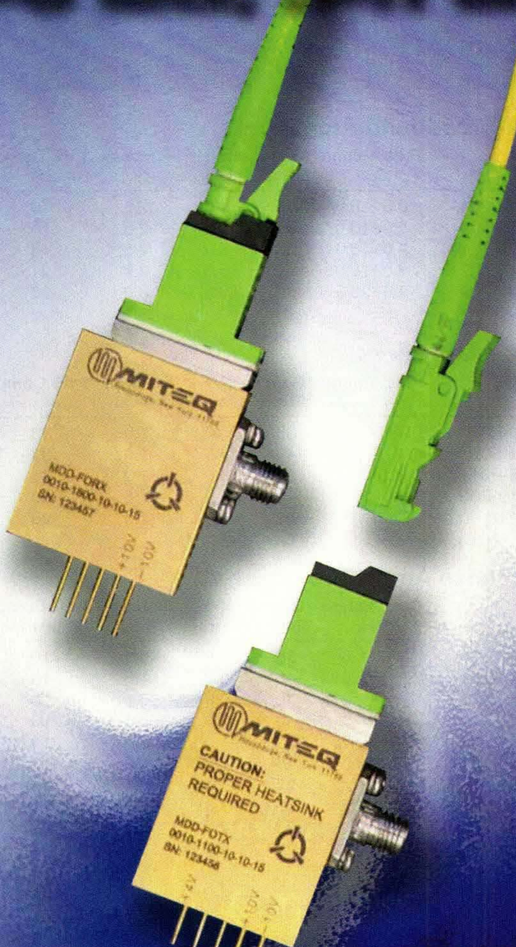
FIBER OPTIC LINKS

.01–3 GHz, .1–6 GHz, .1–11 GHz



FEATURES:

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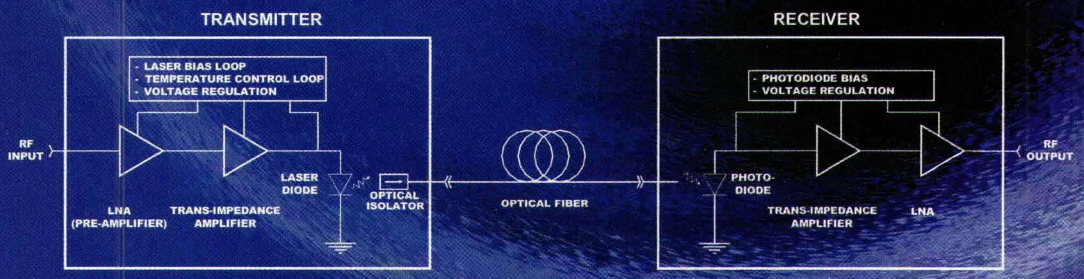
- Low Noise Figure
- No External Control Circuits Required
- Custom Configurations Available

APPLICATIONS INCLUDE:

- EMC Testing
- Antenna Remoting
- Local Oscillator Remoting
- Interfacility Communication Links

Electrical Specifications
(1 Meter of Fiber)

Model	LBL	SCM	MDD
Frequency (GHz)	.01–3	0.1–6	0.1–11
Gain (dB)	10-20 (17 Typ.)	10-20 (18 Typ.)	10-20 (18 Typ.)
Noise Figure (dB, Max.)	15 (10 Typ.)	20 (14 Typ.)	20 (18 Typ.)
Group Delay (ns ptp, Typ.)	0.1	0.1	0.1
VSWR (In/Out)	2:1	2:1	2:1
Phase Noise (dBc, Typ.)	>100	>100	>100
Input Power @P1dB (dBm, Min.)	-14	-14	-14
Spurious Free Dynamic Range (dB/Hz Min.)	100 (105 Typ.)	101 (103 Typ.)	100 (104 Typ.)



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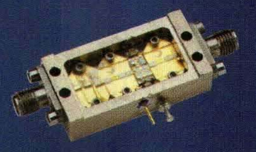
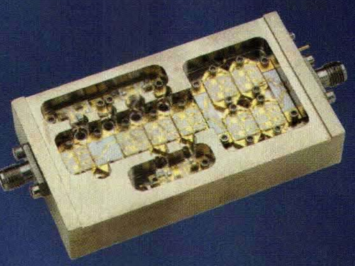


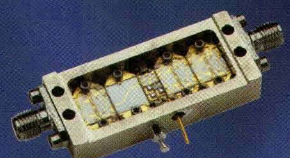


Ultra Broadband Amplifiers

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA018-204	0.5–18.0	25	4.0	2.5	10	20	2.0:1	300
JCA218-506	2.0–18.0	35	5.0	2.5	15	25	2.0:1	400
JCA218-507	2.0–18.0	35	5.0	2.5	18	28	2.0:1	450
JCA218-407	2.0–18.0	30	5.0	2.5	21	31	2.0:1	500
JCA220-209	2.0–20.0	20	6.0	3.0	20	30	2.0:1	500

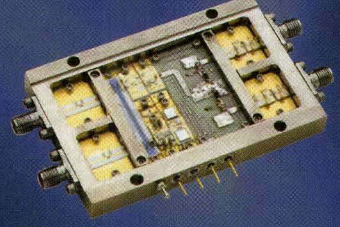
Power Amplifiers

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-P01	1.35–1.85	35	4.0	1.0	33	41	2.0:1	1000
JCA34-P02	3.1–3.5	40	4.5	1.0	37	45	2.0:1	2200
JCA56-P01	5.9–6.4	30	5.0	1.0	34	42	2.0:1	1200
JCA812-P03	8.0–12.0	40	5.0	1.5	33	40	2.0:1	1700
JCA1218-P02	12.0–18.0	22	4.0	2.0	25	35	2.0:1	700



Low Noise Amplifiers

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-1000	1.2–1.6	25	0.8	0.5	10	20	2.0:1	80
JCA12-3001	1.0–2.0	40	0.8	1.0	10	20	2.0:1	200
JCA23-302	2.2–2.3	30	0.8	0.5	10	20	2.0:1	80
JCA34-301	3.7–4.2	30	1.0	0.5	10	20	2.0:1	90
JCA78-300	7.25–7.75	27	1.2	0.5	13	23	2.0:1	120
JCA910-3000	9.0–9.5	25	1.3	0.5	13	23	1.5:1	150
JCA1112-3000	11.7–12.2	27	1.4	0.5	13	23	1.5:1	150
JCA1415-3001	14.4–15.4	35	1.6	1.0	14	24	2.0:1	200
JCA1819-3001	18.1–18.6	25	2.0	0.5	10	20	2.0:1	200
JCA2021-3001	20.2–21.2	25	2.5	0.5	10	20	2.0:1	200



Millimeter Wave Amplifiers NEW

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA2629-201	26.0–29.0	19	5.0	1.5	5	15	2.0:1	100
JCA2629-401	26.0–29.0	35	5.0	1.5	5	15	2.0:1	200
JCA2730-205	27.5–30.0	15	5.0	1.0	15	25	2.0:1	200
JCA2730-302	27.5–30.0	26	5.0	1.0	8	18	2.0:1	150
JCA2730-502	27.5–30.0	43	5.0	1.0	8	18	2.0:1	200
JCA3031-102	30.0–31.0	18	5.0	1.5	8	18	2.0:1	100
JCA3031-302	30.0–31.0	34	5.0	1.5	8	18	2.0:1	200
JCA3031-405	30.0–31.0	40	5.0	1.5	15	25	2.0:1	400
JCA2640-301	26.5–40.0	30	5.0	2.5	0	10	2.0:1	160

Product Options:

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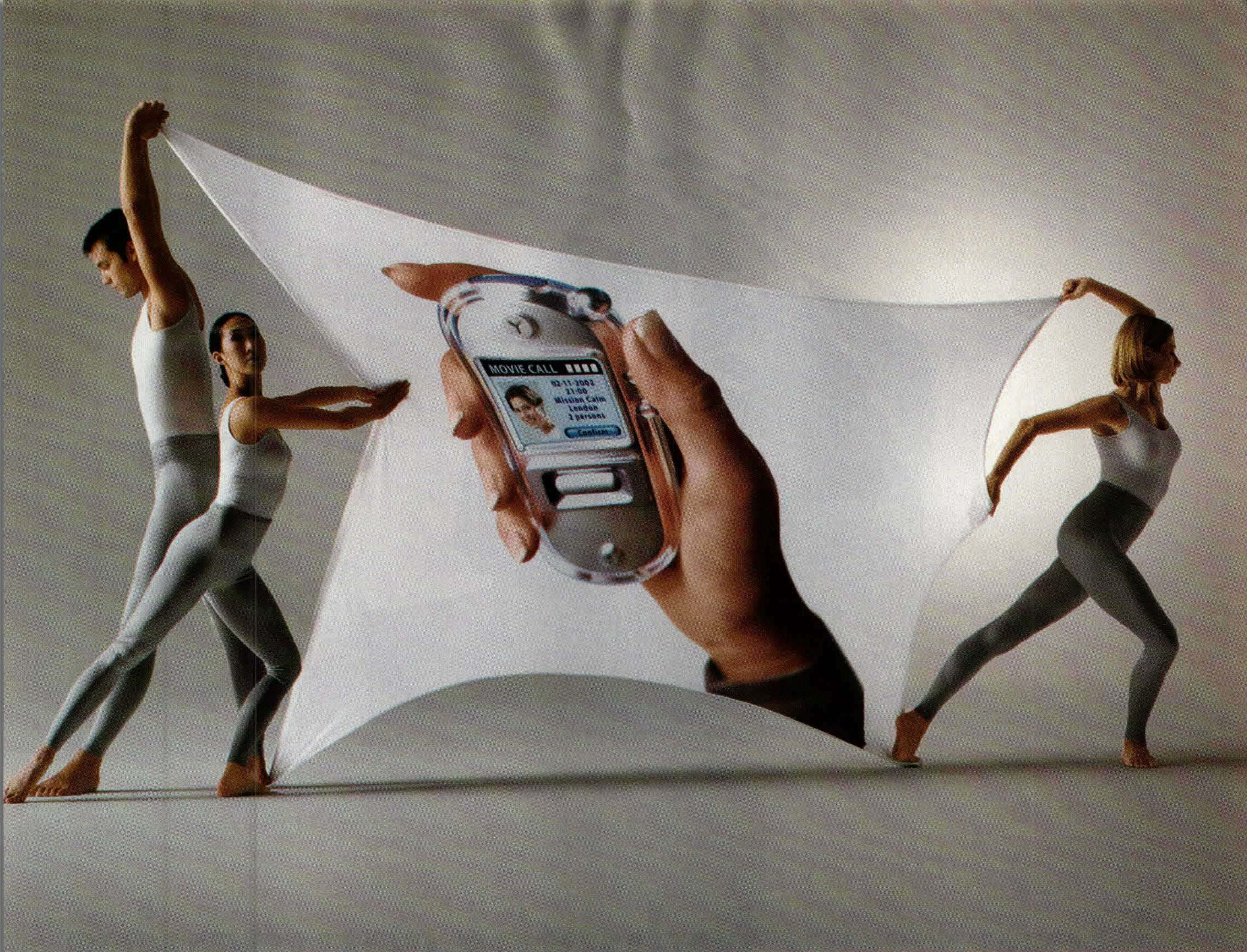

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Electronic Articles

▶▶CONGRATULATIONS for a good article on "Simulators Model System Behavior" in the February issue (p. 33).

Is there a way that we can get this article in electronic form?

Andre C. Kobel
Vice President of Business Development
Elanix, Inc.

Editor's Note: Hello, Andre. Thanks for your kind words on February's system simulator story. It's a part of the software world that I think doesn't get enough exposure, so it was gratifying to get the word out on a pretty good current crop of system simulators. The article in question appears on our website in PDF form. There are PDF files of all the major articles in the issue. To find the article that you're looking for, go to our website at www.mwrf.com. Click on MWRF Archive. When the Archive listings page opens, click on February 2003. The article is in the News section.

2003 Wireless Show

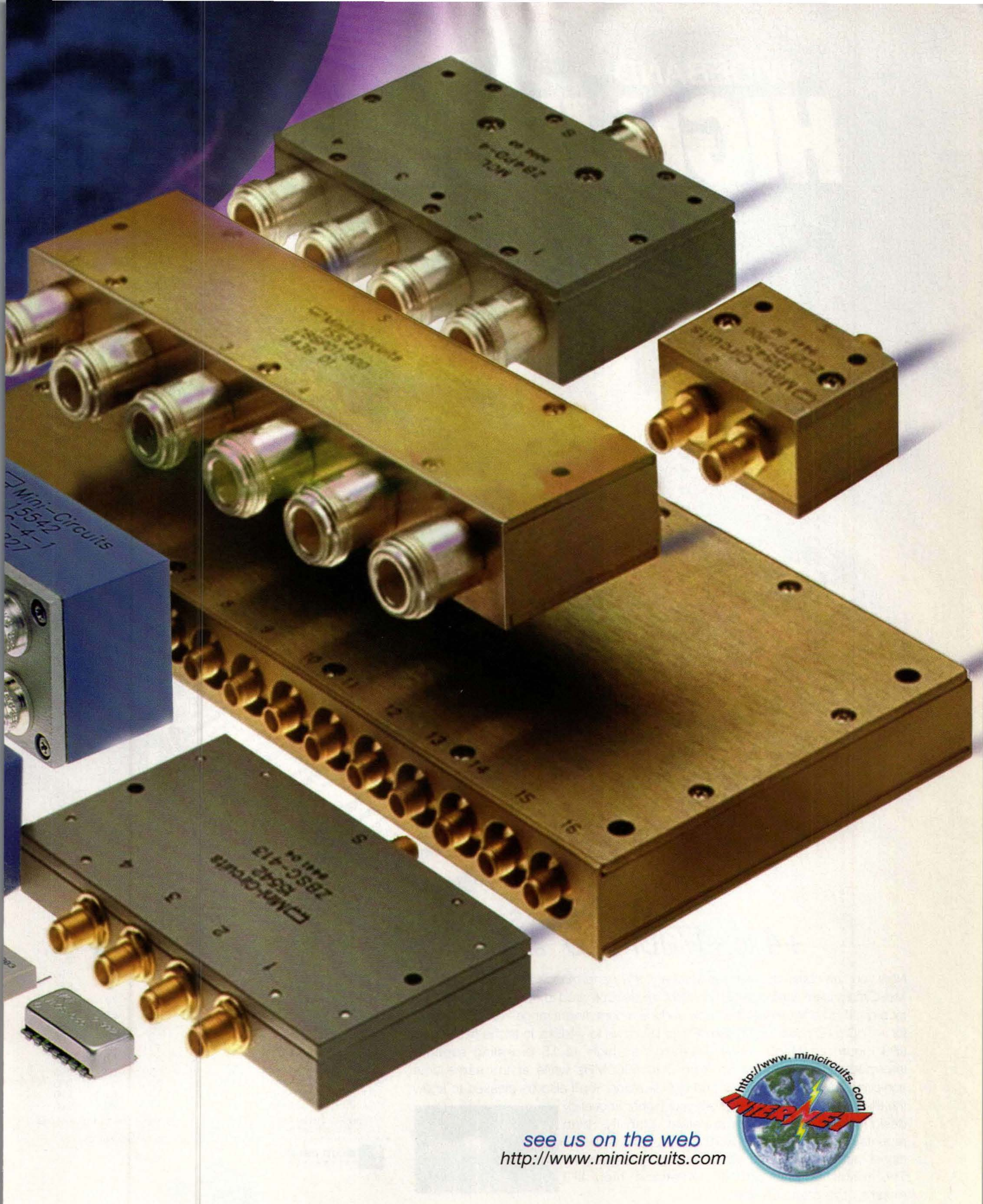
▶▶RAYTHEON RF COMPONENTS had a centrally located booth (#727) at the recent Wireless Systems Design Conference & Expo, which was held in San Jose, CA. This was an excellent location, and we attracted quite a few of the attendees. Although the show was noticeably smaller than last year in terms of attendees and exhibitors, we observed that this was an economic function and certainly not due to a lack of interest. Conversely, the conferences (although I did not personally attend) were reported to be excellent and booked. Also, of the leads that we scanned, 70 to 75 percent are qualified. In other terms, there was a higher concentration of 'true' leads acquired at this show than we acquired at last year's show.

Raytheon RF Components' focus was devoted to the introduction of two new GaAs HBT power amplifiers specifically designed for the WLAN market: RMPA5251-251 (5-GHz InGaP HBT Linear MMIC power amplifier is ideal for use in 802.11a WLAN applications) and the RMPA2453-251 (2.4-to-2.5-GHz InGaP HBT MMIC power amplifier is ideal for use in 802.11b/g applications).

Catherine Austin
Raytheon RF Components

▶▶THE 2003 WIRELESS Systems Design Conference yielded an increased number of good sales leads compared to the 2002 show. This show provides a valuable forum for demonstrating new products and connecting with new customers.

David Wick
Sales Manager
Honeywell RF/Microwave Solutions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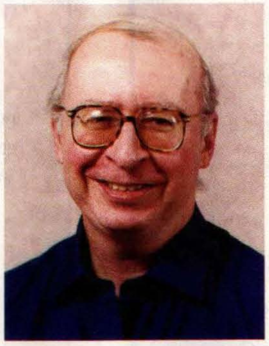
The Military Is Important (Again)



MILITARY ELECTRONICS IS ONCE AGAIN an important component of high-frequency business. News about the conflict in Iraq dominates broadcast airwaves and newsprint, as Coalition forces push for a speedy end to the war. This conflict is similar to the earlier Desert Storm, with our troops braving a hostile environment (sandstorms, heat) as well as the enemy. The technology is improved, however, from the earlier conflict, with enhanced Patriot missiles, for example, demonstrating far more effectiveness in neutralizing enemy Scud missiles now than in Desert Storm.

The RF/microwave industry has long been synonymous with military electronics.

Unfortunately, war is not without loss, no matter how effective the technology. If war is inevitable (until human nature undergoes a fundamental change for the better), then investments in military technology can at least help to minimize loss of life and, hopefully, speed the resolution of a conflict. Of course, a pacifist would argue that more effective military technologies could also make the taking of life more efficient. But most military strategists and officers will admit that most military campaigns try to define and "neutralize" key targets, such as weapons storage facilities and communications installations, rather than targeting personnel.

The RF/microwave industry has long been synonymous with military electronics, given the industry's early roots in radar research and the MIT/Radiation Labs of World War II. Over the last decade, the industry has continued to improve the basic active and passive component technologies that contribute to the sensitivity of radar warning receivers (RWRs), the resolution of tracking radars, and the effectiveness of electronic-warfare (EW) systems. Even with the "distraction" of cellular communications and other alluring wireless markets during the decade of the 1990s, a solid core of microwave companies continued to support military electronics technologies in order to provide the US and her allies with strategic technological advantages.

For these companies, the Military Electronics Show (MES) was started almost three years ago, to provide a meeting place for engineers involved in military electronics of all forms, from amplifiers and computers to software and test equipment. Scheduled for September 16-17, 2003 in the Baltimore Convention Center (Baltimore, MD), the technical conference is co-sponsored this year by the IEEE's Aerospace and Electronics Systems Society. Some of the philosophy behind the event can be found at the MES website (www.mes2003.com); in essence, the show serves as a forum for design engineers to share the challenges they have faced and solutions they have found in working for military customers.

For the sake of our troops, we hope for a rapid conclusion to the Iraq war. For its part, the microwave industry continues to advance many of the key technologies that will give our troops an unbeatable edge.

Jack Browne

Publisher/Editor

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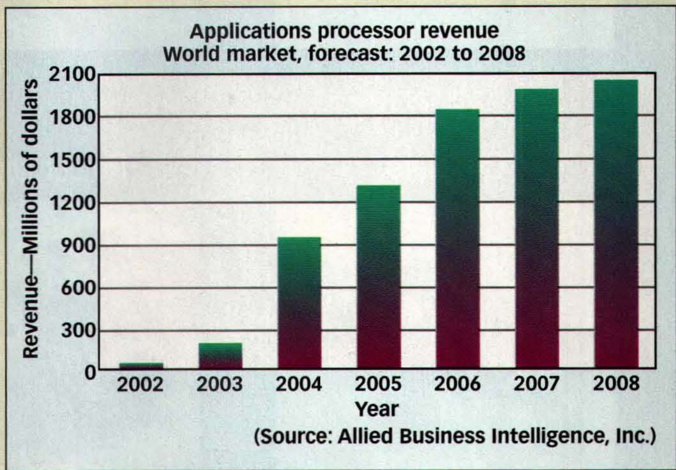
the front end

News items from the communications arena.

Applications Processors Represent A Big Growth Opportunity

OYSTER BAY, NY—There have been many advances in integrated-circuit (IC) technology that deliver the performance demanded by today's cellular handsets. According to an Allied Business Intelligence (ABI) report, "Handset Integrated Circuits: High Demands = Inevitable Integration," the market for handset ICs, currently at $8.7 billion, is expected to grow to approximately $12 billion by 2008 with a compound average annual growth (CAAG) of 5 percent. This available market projection includes consideration of the core components in the communications chain, including digital baseband, analog baseband, power management, RF transceiver, and applications processors.



However, of the core components, the applications processor represents the biggest growth opportunity for handset IC suppliers, with sales to manufacturers expected to reach over $2 billion in 2008 **(see figure)** at a CAAG of 120 percent. One of the reasons for the explosive growth is the expected transition from 2.5G to 3G networks, coupled with ever-increasing demands for added functionality in handsets.

"The key to this market going forward is for IC suppliers to support handset vendors with a complete solution," said Tim Shelton, senior analyst at ABI and the report's author. "The applications processor is the next burgeoning opportunity for IC suppliers to capitalize on."

Two Firms Announce WLAN LIcensing Partnership

MILPITAS, CA AND SAN JOSE, CA—Intersil Corp. and ParthusCeva, Inc. have announced a partnership to license Intersil's 802.11 WLAN IP to third parties.

"This partnership is a very significant development which will accelerate the deployment of WLAN technology across both business and consumer applications. Intersil is the acknowledged leader in 802.11 wireless solutions and ParthusCeva has a proven track record of delivering complex wireless technology under an IP licensing model," said Allen Nogee, senior analyst at In-Stat/MDR. "This unique combination can unlock the enormous potential of WLAN technology."

ParthusCeva will provide wireless IP experience, sales, marketing, and customer support in licensing Intersil's 802.11 Prism® Intellectual Property (Baseband Property and Medium Access Controller) to the electronics industry. PRISM solutions are the number-one deployed 802.11 WLAN technology in the industry. In addition, Intersil will supply PHY (radio front-end) products and reference designs—delivering a complete WLAN product solution to licensees. This up-integration strategy will enable new, wireless-capable products that will serve growing consumer demand for wireless connectivity wherever they live or work.

"The licensing of our WLAN IP is one of the next steps in addressing the needs of a growing market in which Wi-Fi is becoming pervasive and working its way into a diverse and exciting set of applications," said Larry Ciaccia, VP/GM of Intersil's Wireless Networking Product Group.

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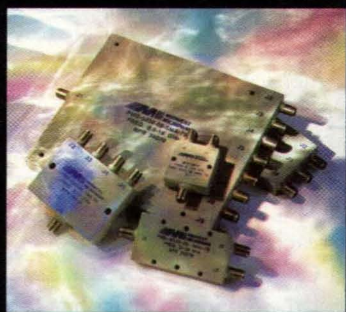

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RFMD Announces GaN Process Technology Milestone

GREENSBORO, NC—RF Micro Devices, Inc. (RFMD), a provider of proprietary RF integrated circuits (RF ICs) for wireless-communications applications, has announced the achievement of a milestone toward the commercialization of gallium-nitride (GaN) RF power technology. RFMD has successfully grown, fabricated, and packaged GaN power transistors achieving 28-W performance with continuous-wave (CW) operation at 20 V. These GaN power transistors are fabricated from the current 0.9-μm process and exhibit 10 dB of linear gain. The transistors were used to develop 20-W CW power amplifiers (PAs) for UMTS applications.

William Pratt, RFMD's chief technical officer, commented, "We're very enthusiastic about achieving these milestones in GaN power technology, which we believe demonstrate our technology leadership and our ongoing commitment to commercializing the most promising future semiconductor technologies. We believe GaN can conceivably lower the overall cost of wireless base stations and thereby prove to become a disruptive and revolutionary technology in the wireless-infrastructure space."

RFMD has also demonstrated 7-W wideband GaN PAs designed for DCS (1800 to 1880 MHz), PCS (1930 to 1990 MHz), and UMTS (2110 to 2170 MHz) wireless-infrastructure applications. The GaN PAs exhibit 11 dB of gain at 20-V operation, with gain slope of ±0.2 dB over the entire range and better than ±0.1 dB over the DCS and PCS bands. By exhibiting flat gain over a broad frequency range, the GaN PAs enable a single PA solution over DCS, PCS, and UMTS wireless-infrastructure bands. The matched PA exhibits an output return loss of −12 dB over the band with a typical input return loss of −11 dB at midband.

Dr. Jeff Shealy, vice president of the infrastructure amplifier product line at RFMD, said, "The advantages of gallium nitride are clearly demonstrated in the broadband power and gain performance of these matched amplifiers. This wideband performance is extremely difficult to achieve using semiconductor technologies that are commercially available today."

During the current quarter, RFMD delivered packaged engineering samples of the 7-W wideband GaN PAs to leading wireless-infrastructure OEMs.

Public WLAN Market Prospects Remain Strong In US & Europe

CAMBRIDGE, ENGLAND—Growth of the public wireless-local-area-networking (P-WLAN) market is set to continue in both the USA and Western Europe, according to a report by Analysys, a global telecommunications, IT, and media adviser. This growth is being driven by business travellers' appetite for cheap and fast remote access to the Internet.

The report, *Public WLAN Access in Western Europe and the USA: market analysis and forecasts*, anticipates that revenue will grow from $33.4 million in 2002 ($10.9 million in Western Europe and $22.5 million in the US) to $5.5 billion by 2007 ($2.64 billion in Western Europe and just under $2.8 billion in the US).

Hotspots, which are currently being installed in airports, hotels, conference facilities, cafés, restaurants, and rail stations, are estimated to grow from 4800 in 2002 (1400 in Western Europe and 3400 in the USA) to 57,000 by 2007 (30,000 in Western Europe and 27,000 in the US).

"Whilst take-up of public WLAN services has been slower than we anticipated, it still represents a significant opportunity for operators and other service providers," stated Maja Kecman, main author of the report. "In both Europe and the USA, telecoms operators have shown interest in the WLAN market as a complement to their existing networks, but have been cautious about investing in an uncertain market where there are still technological and regulatory issues to be resolved."

"Whilst take-up of public WLAN services has been slower than we anticipated, it still represents a significant opportunity for operators and other service providers."

Market uncertainty is compounded by the fact that no single business model has yet emerged, commented the authors. The report outlines five main business models, the most common of which involves the hotspot-site owner and operator [or wireless Internet service provider (WISP)] acting as the main players in the P-WLAN value chain.

"We expect the dominant business models to evolve significantly in the next three or four years," said San Francisco-based report co-author, Monica Paolini. "By 2007, the US market will be characterized by a non-integrated value chain, with retail service providers not having exclusive control of the network infrastructure. In Europe, we expect fixed and mobile operators to prevail as they are able to leverage their existing customer base and backhaul agreements more effectively."


VERSION / NINE
9

Ansoft Begins Commercial Shipments Of Ansoft Designer

PITTSBURGH, PA—Ansoft Corp. has begun commercial shipments of Ansoft Designer™, a software product available for the design of high-frequency microwave and RF circuits and systems.

"The long history of dedication to accuracy makes the Ansoft simulation tools the best in class for RF and microwave design," said William Martin, principal staff engineer at Motorola, "which is why I rely on Ansoft for my RF integrated circuits and discrete circuit designs."

"The long history of dedication to accuracy makes the Ansoft simulation tools the best in class for RF and microwave design."

Ansoft Designer combines time-domain, frequency-domain, and system-level analysis tools to fully investigate the relationship between physical aspects and electrical performance before actually fabricating circuit, subsystem, or system components.

With the software's release, Ansoft introduces Solver on Demand™, a technology that gives every user, from novice to veteran, access to the most appropriate solver for a given design problem. With Ansoft Designer, all tools are always available for use, regardless of the task being performed at a specific time. The result is greatly reduced design time/complexity and a greater assurance that a circuit will operate as expected without further iterations.

Ansoft Designer can operate as a stand-alone tool or be incorporated into existing design flows, based on third-party EDA tools from vendors such as Cadence, Synopsys, Mentor Graphics, and Zuken.

Kudos

PALO ALTO, CA—Agilent Technologies, Inc. announced that BAE SYSTEMS has selected Agilent to provide a comprehensive package of RF and microwave EDA software, support, and on-site consulting. The Agilent Advanced Design System (ADS) electronic-design-automation (EDA) software will help streamline design processes and improve productivity of BAE SYSTEMS' RF and microwave module and monolithic-microwave-integrated-circuit (MMIC) development for communications, aerospace, and defense applications.

VISTA, CA—Palomar Technologies, a manufacturer of automated, high-precision assembly systems, announced that Hologic Corp.'s Direct Radiography Division has selected Palomar's 3500-II automatic component assembly machine to automate production of hybrid microelectronics used in its DirectRay radiographic imaging technology.

Direct Radiography uses Palomar's 3500-II to automate assembly in two areas:

1. Fabricating microelectronic hybrids assemblies for digital medical-imaging applications.
2. Populating hybrid microelectronics subassemblies onto TFT flat panels for use in X-ray detectors for general radiography and mammography.

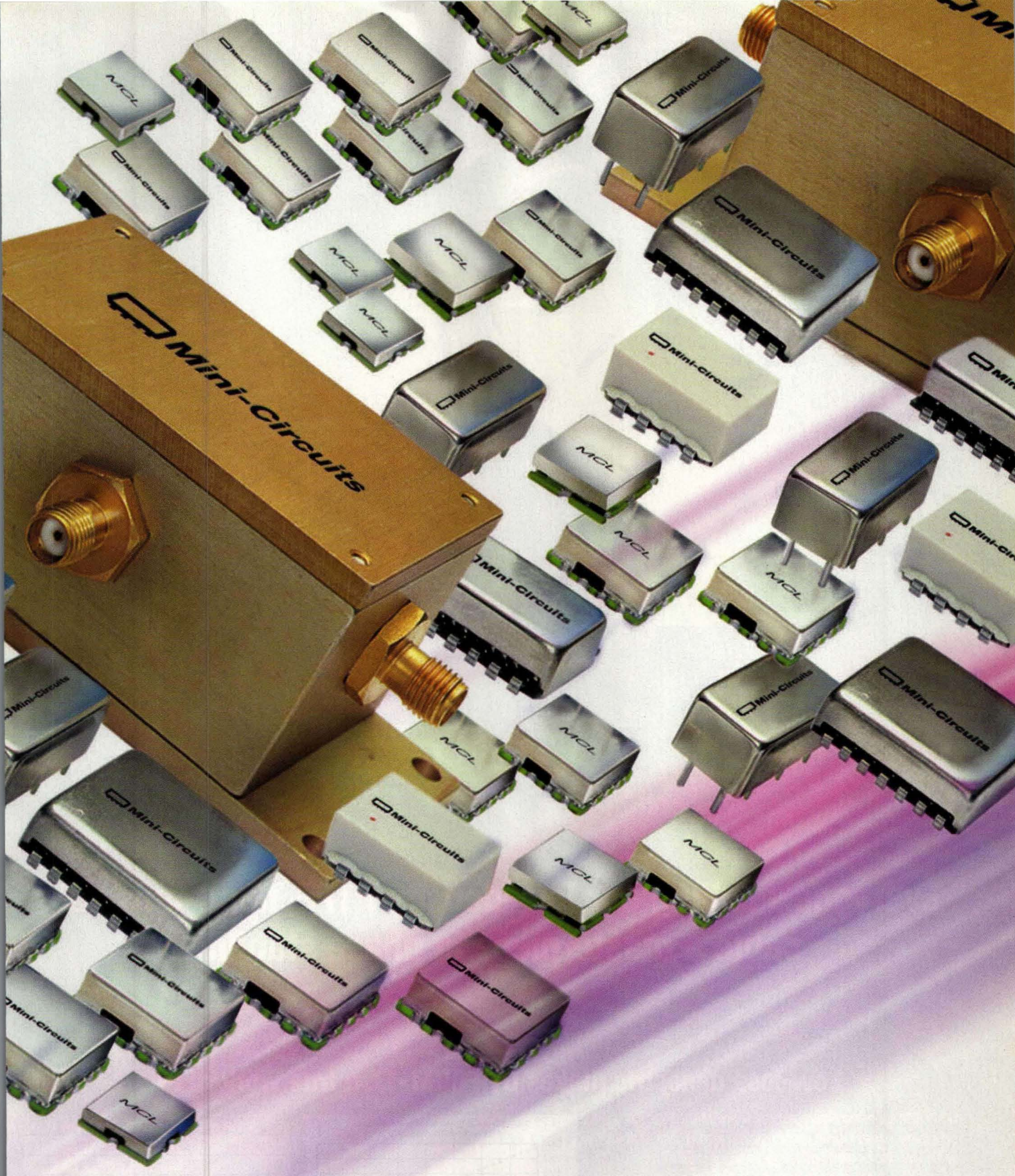
Both are are components of Hologic's DirectRay technology, which uses a direct-conversion process to convert X-ray energy into a digital signal that produces a high-quality image with no intermediate steps.

SAN DIEGO, CA—StratEdge has received ISO 9001:2000 certification. Achieving ISO 9001:2000 certification indicates that StratEdge meets specific requirements for a quality-management system that demonstrates StratEdge's ability to consistently provide product that meets customer and applicable regulatory requirements and aims to enhance customer satisfaction. ISO 9001:2000 is the latest 9000 family standard defined by the International Organization for Standards and must be adopted by 2004.

ORLAND PARK, IL—Andrew Corp. recently completed a distributed communications project for Shanghai Mobile Communications Co. Ltd. (SMCC) that extended Global System for Mobile Communications (GSM) coverage throughout the Yan'an East Road Tunnel in the downtown area of Shanghai, China, including the section of road tunnel running beneath the Huangpu River. The extended GSM system enables Shanghai's mobile-phone users to maintain their phone connections within over 2 km of road tunnel.

CARSON CITY, NV—The Micromanipulator Co. has been awarded patents for its NANO-100™ SEM-based Probing System for probing structures less than 300 nm (below visible and NUV microscope resolutions). Patents #6,191,598B1 and #6,198,299B1 incorporate a method and system for probing with electrical test signals on an integrated-circuit (IC) specimen using a scanning electron microscope (SEM).

RANDOLPH, MA—Emerson & Cuming Microwave Products, Inc. has achieved ISO 9001:2000 certification. MRF


Mini-Circuits
MCL

Linearizer Hikes PA Efficiency

This simple analog circuit requires only a handful of components to improve the linearity and/or efficiency of base-station and handset power amplifiers.

JACK BROWNE
Publisher/Editor

Analog approaches may reap huge benefits for digital communications systems. That is the intention of the engineers at Cigma Technologies (Allendale, NJ), who have developed a unique analog predistortion-linearizer (PDL) circuit that promises to make wireless power amplifiers (PAs) at least 50-percent more efficient and consequently much smaller than designs incorporating the best alternative lineariza-tion schemes, including feedforward techniques. The solution has been found to be effective with all wireless formats tested, including IS-95 code-division multiple access (CDMA), wideband CDMA (WCDMA), Universal Mobile Telecommunications Services (UMTS), Global System for Mobile Communications (GSM), and Enhanced Data-rate for GSM Evolution (EDGE) formats.

According to Cigma's president and chief operating officer (COO), Young Sohn, "New amplifiers built with this RF predistortion linearizer will be up to 50 percent more compact, will increase efficiency by at least 50 percent, and can be priced at 30 percent less than existing products." Sohn, having spent many fruitful years with software giant Oracle, headed an investment group that acquired Cigma this past year and established two operating divisions: a wireless amplifier group and a test and measurement instrument group (which will continue to operate under the well-established brand name Protek).

The PDL employs proprietary patent-pending Multi-Element RF Predistortion (MERP) technology to achieve the gain and phase control needed to linearize broadband single-channel and multichannel PAs. According to Richard Lisco, Cigma's vice president of engineering, the company's engineers evaluated a variety of techniques for linearization: "We considered ways to make a better linearizer, without using conventional, inefficient feedforward linearization. For example, we looked at distortion feedback and envelope feedback, but all of these approaches are bandwidth limited."

After a period of extensive research, the Cigma engineering team had an analog predistorter working in the laboratory. "The circuit is very simple and amenable to integration, and can be realized with very low-cost components," Lisco notes. The MERP PDL technology can be applied to both base-station amplifiers as well as handsets and cellular telephones. In essence, the PDL circuit consists

Cigma Technologies' Young Sohn (right) and Rich Lisco hold an analog PDL circuit that can improve the linearity and efficiency of wireless/cellular base-station PAs.

of two voltage-controlled nonlinear modulators. The outputs of the modulators are summed to generate the desired gain and phase-transfer functions. Linearization is achieved by predistorting the amplitude and phase components of the input signal to the RF PA in a manner to correct for the amplifier gain and phase non-linearity.

Cigma confirms that the circuit has been tested with a number of in-house PA designs as well as PAs from Motorola (Schaumburg, IL) and handset RF IC PA modules, with as much as 15-dB reduction in distortion compared to tests run on the same amplifiers without the PDL circuit. Lisco points out that the PDL can also be used to improve amplifier efficiency, "or to transform a single-carrier amplifier into a multi-carrier amplifier." When used in a closed-loop approach, the PDL can deliver an additional 5 to 6 dB in margin. "For example," offers Lisco, "a manufacturer with a 20-W amplifier having a certain level of linearity may be able to achieve 30 W output power with that same level of linearity." The circuit can increase output power for the same distortion performance, or maintain the same output power at a lower distortion level.

The analog linearizer **(see figure)** is designed for use with low-level input signals from –10 to 0 dBm. It is currently available in three basic versions for a variety of different operating bands. The basic model is the CT-PDL, with versions for 800 to 900 MHz, 1800 to 2100 MHz, and 2400 MHz. Optimally, the device is inserted prior to a PA's driver-amplifier input. The CT-PDLU is a version of the circuit (available in the same frequency bands) with 0-dB insertion loss to ease applications having limited available gain. Finally, the CT-PDLC is a closed-loop, adaptive version of the linearizer circuit complete with microcontroller-based automatic gain control, automatic pre-distorter tuning algorithms to maximize the signal to IMD ratio, and spectrum-monitoring capabilities for remote system provisioning and diagnosis. The complete module includes an RS-232 interface for alarm status and spectrum display. The microcontroller can set gain levels auto-

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• SWM-2-50DR	DC-4.5	55	0.7	25	5.30
■ SWMA-2-50DR	DC-4.5	65	0.7	25	5.30
• ZASW-2-50DR	DC-5	90	1.7	20	79.95
■ ZASWA-2-50DR	DC-5	90	1.7	20	79.95

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matically while also simplifying the calibration process, without the need of a pilot tone.

In-house demonstrations and displays performed at the recent CTIA event (New Orleans, LA) have shown the PDLs to achieve better than 50-percent efficiency improvement when used with a multicarrier amplifier operating with four carriers (an operational bandwidth of about 80 MHz). The demonstrations also revealed a better than 10-dB improvement in distortion reduction. The beauty of the adaptive, closed-loop version of the circuit, notes Lisco, is its ability to maintain linearity even under

In-house demonstrations and displays performed at the recent CTIA event (New Orleans, LA) have shown the PDLs to achieve better than 50-percent efficiency improvement when used with a multicarrier amplifier operating with four carriers (an operational bandwidth of about 80 MHz).

extreme changes in environmental and operating conditions.

The PDL circuitry offers amplifier designers a chance to dramatically improve the performance of their existing single-carrier and multicarrier designs. The analog circuit provides open-loop (nonadaptive) or closed-loop (adaptive) corrections in PA performance that can translate into less power consumed in cellular base stations and more talk time per battery charge for cellular handsets. For a more detailed technical look at this innovative analog linearizer circuit, don't miss the follow-up PDL article in the May issue of *Microwaves & RF.* MRF

Capacitors Optimize Microwave Power Designs

DESIGNED SPECIFICALLY FOR RF and microwave power circuits and systems, the 600F series of multilayer-chip (MLC), high-quality-factor (high-Q) capacitors is ideal for use in cellular base stations, broadband wireless equipment, digital microwave radios, and low-phase-noise oscillators. The capacitors, which are available in values from 0.1 to 240 pF, offer low effective series resistance (ESR), high quality factor (Q), and 250-V working voltage in a standard 0805 EIA size. The capacitors, which are well suited for surface-mount-technology (SMT) applications, are formed with an environmental friendly tin over nickel barrier termination material for superior heat-conducting properties. The 600F series capacitors exhibit a temperature coefficient of capacitance of 0 ±30 PPM/°C from –55 to +125°C.

American Technical Ceramics Corp., One Norden Lane, Huntington Station, NY 11746-2142; (631) 622-4700, FAX: (631) 622-4748, e-mail: sales@atceramics.com, Internet: www.atceramics.com.

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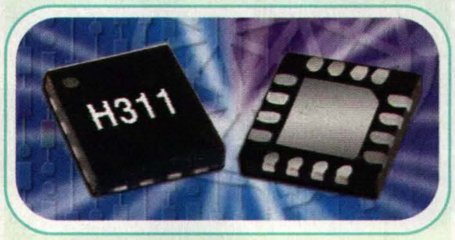
BROADBAND ENOUGH FOR a wide range of wireless applications, the model HMC311LP3 monolithic-microwave-integrated-circuit (MMIC) gain-block amplifier operates from DC to 6 GHz. It can be used as a cascadable 50-Ω gain stage or as a local-oscillator (LO) buffer amplifier to provide as much as +17 dBm output power; the typical output power at 1-dB compression is +15.5 dBm over the full band. The MMIC amplifier, which is based on InGaP HBT technology, achieves an output third-order-intercept point of +32 dBm with typical full-band return loss of 15 dB and typical noise figure of 4.5 dB. The typical isolation is 18 dB.

Hittite Microwave Corp., 12 Elizabeth Dr., Chelmsford, MA 01842; (978) 250-3343, FAX: (978) 250-3373, Internet: www.hittite.com.

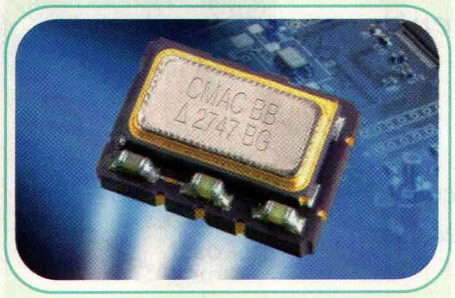


HITTITE'S HMC311LP3 MMIC GAIN-BLOCK AMPLIFIER

Tiny TCXOs Lock Next-Generation GPS

DEVELOPERS OF NEXT-GENERATION Global Positioning System (GPS) receivers and equipment can benefit from the stability offered by the new line of temperature-compensated crystal oscillators (TCXOs). The GPS-TCXO sources measure just 5 × 7 mm and exhibit very low microfrequency jumps of less than 5 PPB measured over 100-ms intervals. The TCXOs can also be specified with peak-to-peak frequency perturbations of only 0.4 PPM measured over small ambient-temperature changes (such as 2°C increments). Models are also available with frequency stability of ±0.5 PPM for temperature ranges as wide as –40 to +85°C. The oscillators, which exhibit negligible aging characteristics (no aging is specified), are available for standard GPS clock frequencies, including 10, 12.8, 16.3676, 19.44, 20.0, and 38.88 MHz.

C-MAC MicroTechnology, a Solectron Co., 4222 Emperor Blvd., Suite 300, Durham, NC 27703-8466; (919) 474-3500, FAX: (919) 941-0530, e-mail: cmac.microtechnology@solectron.com, Internet: www.cmac.com.



C-MAC MICROTECHNOLOGY'S TCXOS

Budget Analyzer Scans 9 kHz To 3 GHz

WELL SUITED FOR wireless design and production testing, the 2397 spectrum analyzer offers unparalleled value for spectrum measurements from 9 kHz to 3 GHz. Priced at under $7000, the spectrum analyzer offers sweep speeds of 50 ms to 1000 s, with resolution-bandwidth filters from 300 Hz to 3 MHz. The instrument covers frequency spans from 100 Hz/div to 300 MHz/div and allows operators to place as many as nine measurement markers for more detailed analysis. The 2397 weighs just over 20 lbs. and includes standard GPIB and RS-232 interfaces for connection to external computers.

IFR, An Aeroflex Co., 10200 West York St., Wichita, KS 67215-8999; (800) 835-2352, (316) 522-4981, e-mail: info@ifrsys.com, Internet: www.ifrsys.com.

IFR'S 2397 SPECTRUM ANALYZER

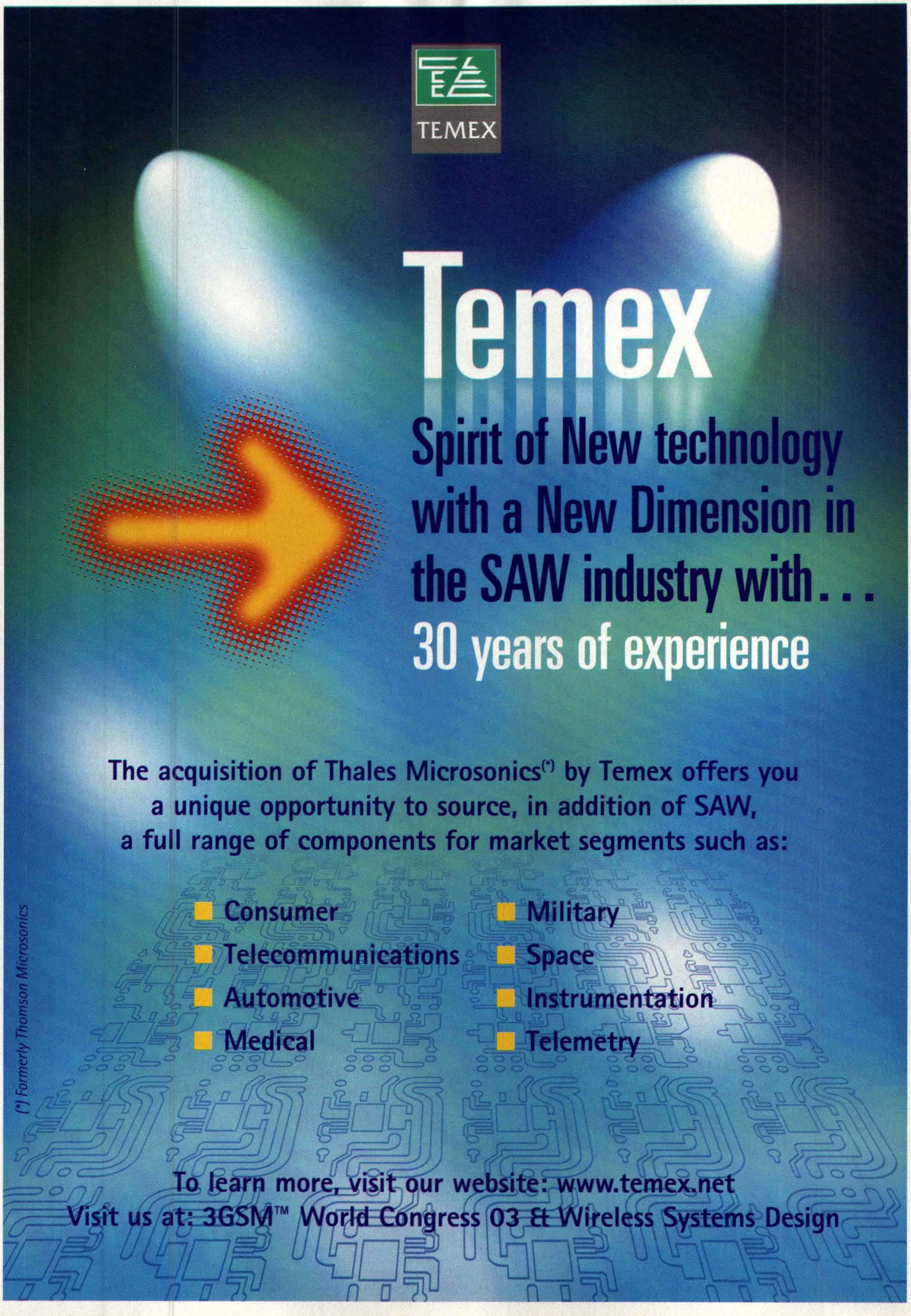
Congressmen Rip Iraq GSM Plan

IN A LETTER TO US Defense Secretary Donald Rumsfeld, California Congressman Darell Issa and a growing number of his colleagues criticized US Army plans to build a Global System for Mobile Communications (GSM)-based wireless network in Iraq, according to Ovum, a European analyst company. Issa is in opposition to the resulting business that he presumes would go to French and German companies like Alcatel and Siemens. Issa decried that fact that "because of ill-considered planning, the US government will soon hand US taxpayer dollars over to French, German, and other European cell-phone equipment companies."

Code-division multiple access (CDMA) would be a better choice for the US Army to consider, Issa claimed, because it is "widely recognized as technically superior" and "provides all necessary access for law enforcement in post-conflict Iraq." In addition, Issa claimed that "hundreds of thousands of American jobs depend on the success of US-developed wireless technologies like CDMA." Issa represents the 49th District of California, north of San Diego. San Diego is home to QUALCOMM, a CDMA powerhouse. (QUALCOMM contributed to Issa's 2002 political campaign.) The US Department of Defense (DoD) has not published a reply to Issa's letter.

Ovum countered that GSM is the dominant technology in Iraq's neighboring countries of Turkey, Israel, Kuwait, and Saudi Arabia. Building a GSM network in Iraq is a better solution for future roaming capability and device interoperability, factors which are very important in integrating Iraq economically into the region, Ovum opined. More practically, Ovum claimed, US soldiers using CDMA devices in Iraq would still need to use GSM phones when they are back in regional bases outside the country.

Ovum claimed that there is irony in Issa's claims since the GSM and CDMA camps are partnering more than ever before. The wireless industry now realizes that subscribers care less about the technology than about the services that the technology enables and how much it costs. Solutions are global and collaboration is key, stated Ovum. MRF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the SAW industry with...
30 years of experience
The acquisition of Thales Microsonics(*) by Temex offers you
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a full range of components for market segments such as:
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Medical
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Instrumentation
Telemetry
To learn more, visit our website: www.temex.net
Visit us at: 3GSM™ World Congress 03 & Wireless Systems Design
(*) Formerly Thomson Microsonics

CONTRACTS

Rockwell Collins—Announced that its Kaiser Electroprecision company has been awarded a contract for the design and development of the horizontal stabilizer trim actuator (HSTA) and sensor package for the new Falcon 7X business jet by Dassault Equipements, a division of Dassault Aviation.

The actuator for the Falcon 7X incorporates three independent means of drive using direct-current electric motors. The design is dual-load-path redundant throughout, and includes a secondary inverted thread nut and safety tie rod on the ballscrew to optimize safety and reliability. The system architecture addresses the stringent FAR/JAR requirements now associated with the certifiability of new HSTA's.

AT&T Government Solutions—Has been awarded a $3.5 million contract from the Federal Trade Commission (FTC) to develop and implement a national registry containing phone numbers of consumers who do not wish to be contacted by telemarketers.

Beginning this summer, AT&T Government Solutions will make it possible for consumers to enter their phone numbers into the registry either by phone or via a website. Telemarketers will be required to download the database of 'do not call' numbers every quarter and discontinue telemarketing to these numbers. As many as 60 million consumers may use the registry when it is available later this year.

The initial $3.5 million award runs through September 2003. The contract allows the FTC to extend the award for up to nine additional years.

Reynolds Industries—Announced that NASA has awarded them a Phase One SBIR contract for the development and qualification of improved miniature high-voltage connectors for deep-space use.

UTStarcom, Inc.—Has signed contracts worth approximately $50 million with China Netcom Corp. for new and expansion deployments of its IP-based Personal Access System (PAS) in several northern cities in China.

Motorola—Has been commissioned by the Hong Kong Police to deliver its third-generation Command and Control Communications system (CC3). The value of this contract to Motorola is $69 million and includes nine-year maintenance of the system.

FRESH STARTS

SoloMio Corp. and Telecom Media Networks (TMN)—Announced that they are partnering in Spain to deliver systems integration and strategic consulting expertise to SoloMio customers.

As part of the agreement, TMN will be establishing a new center of competence and excellence in Spain to meet future customer requirements and demand expected from the Spanish market, which is expected to grow exponentially. A first competence center is already in place in France. Leveraging a two-year relationship with TMN as a partner for its Real-time Call Services, SoloMio will use the agreement to extend TMN's systems and consulting expertise to ensure rapid integration and deployment of their Smart Call Services Platform into operators' network environment and services strategy.

MMD Components—Have purchased the rights to the entire product portfolio of Monitor Products. The addition of Monitor's lines of crystals, oscillators, and crystal filters to MMD's line of products expands the scope of their offering, especially in the area of frequency control.

The crystals, oscillators, VCXOs, TCXOs, and OCXOs are all available with the same specs that were available from Monitor.

Fujitsu Microelectronics America—Moved its corporate headquarters to 1250 East Arques Ave., Sunnyvale, CA 94085-5401 on March 17. The move brings FMA to Fujitsu's corporate campus, alongside Fujitsu Technology Solutions, Inc. and other Fujitsu companies.

Accent Optical Technologies—Announced the placement of a high-power DiVA system at Modelithics, Inc. This is the second DiVA placed at Modelithics. The first, a DiVA 225 capable of 25-V and 1A operation, was installed in April 2002 and is being used for developing non-linear models for low- and medium-power transistors and diodes, based on pulsed IV measurements made on packaged, chip, and on-wafer device samples.

Phihong—Moved their US headquarters to a new and expanded facility in Fremont, CA. The new 30,000-sq.-ft. building will house and increased R&D team, as well as additional sales and engineering support staff.

The contact information for the new location is: Phihong U.S.A., 47800 Fremont Blvd., Fremont, CA 94538; (510) 445-0100, FAX: (510) 445-1678, e-mail: usasales@phihongusa.com.

NetVendor and Teradyne—Announced that the two companies have completed the sale of Teradyne's Manufacturing Software Group (MSG) to NetVendor, Inc. The two groups, both located in the metro Atlanta, GA area, have merged to become Visiprise, Inc.

The new corporation will focus on developing, marketing, and selling software solutions for discrete manufacturers, including manufacturing-execution-systems (MES) software, quality-management software, and new product introduction software. The Alpharetta, GA-based facilities that had served Teradyne MSG have become the new corporate headquarters of Visiprise.

Intersil Corp. and ParthusCeva, Inc.—Announced a partnership to license Intersil's 802.11 WLAN IP to third parties.

Link Microtek—Has gained BS EN ISO 9001:2000 approval for its company-wide quality-management system.

This latest approval extends the scope of the 1997 certificate to cover the design, manufacture, and sale of RF and microwave components, systems, and instrumentation. MRF


KERYELL

Keryell Joins Link Microtek In Sales Position

MICK KERYELL has been appointed to the position of microwave product engineer for the North and Midlands of England by Link Microtek Ltd. Keryell was formerly employed in sales at several firms, including Tekelec and Frequency Techniques.

The ERNI Group of Companies—WENDY WUERTH-GRIGGS to vice president of sales and marketing for the Americas; formerly co-founded and worked as vice president of sales and marketing at Kycon, Inc.

The PXI Systems Alliance (PXISA)—BOB STASONIS to president; remains as marketing manager with Teradyne. Also, LOOFIE GUTTERMAN to director of marketing; continues as president at Geotest.

Agere Systems—JOHN W. GAMBLE JR. to executive vice president and CFO; formerly senior vice president and business controller.

EMS Technologies, Inc.—ROBERT P. CROZER to the board of directors; formerly chairman of the board at Keebler Foods Co. Also, DR. JOHN R. KREICK to the board of directors; formerly president of the Sanders division of Lockheed Martin Corp. and a Lockheed corporate vice president. In addition, DON T. SCARTZ to executive vice president; formerly CFO.

Kyocera Wireless Corp.—JIM KELLY to vice president of engineering to oversee the Development Engineering Group; formerly president and CEO at Skydesk, Inc.

MCE/Metelics, Inc.—GARY COONCE to marketing manager; formerly a sales representative with Jay Stone Associates.

Bisco Industries, Inc.—LAURIE GEBAROFF to Southern regional sales manager; formerly Southern California sales manager. Also, LISA COOK to Eastern regional sales manager; formerly area manager over part of the Midwest and Eastern areas. In addition, ROBERT RIST to Northern region sales manager; formerly Western regional sales manager.

International Manufacturing Services, Inc. (IMS)—DAVID J. LONDON to director of sales and marketing; formerly employed as a sales and marketing consultant, specific to the RF and microwave-component industry, for DJLA Consulting.

Sandbridge Technologies, Inc.—TANUJ RAJA to the HY-SDR Research Committee; remains as vice president for business development.

Sabritec—PETER BOREHAM to European business development manager; formerly technical manager for Brand Rex Ltd. and engineering manager for Deutsch Ltd. EMC Business.

Lamina Ceramics—DAVID MCCONAGHY to vice president of sales; formerly vice president of sales at TransEDA.

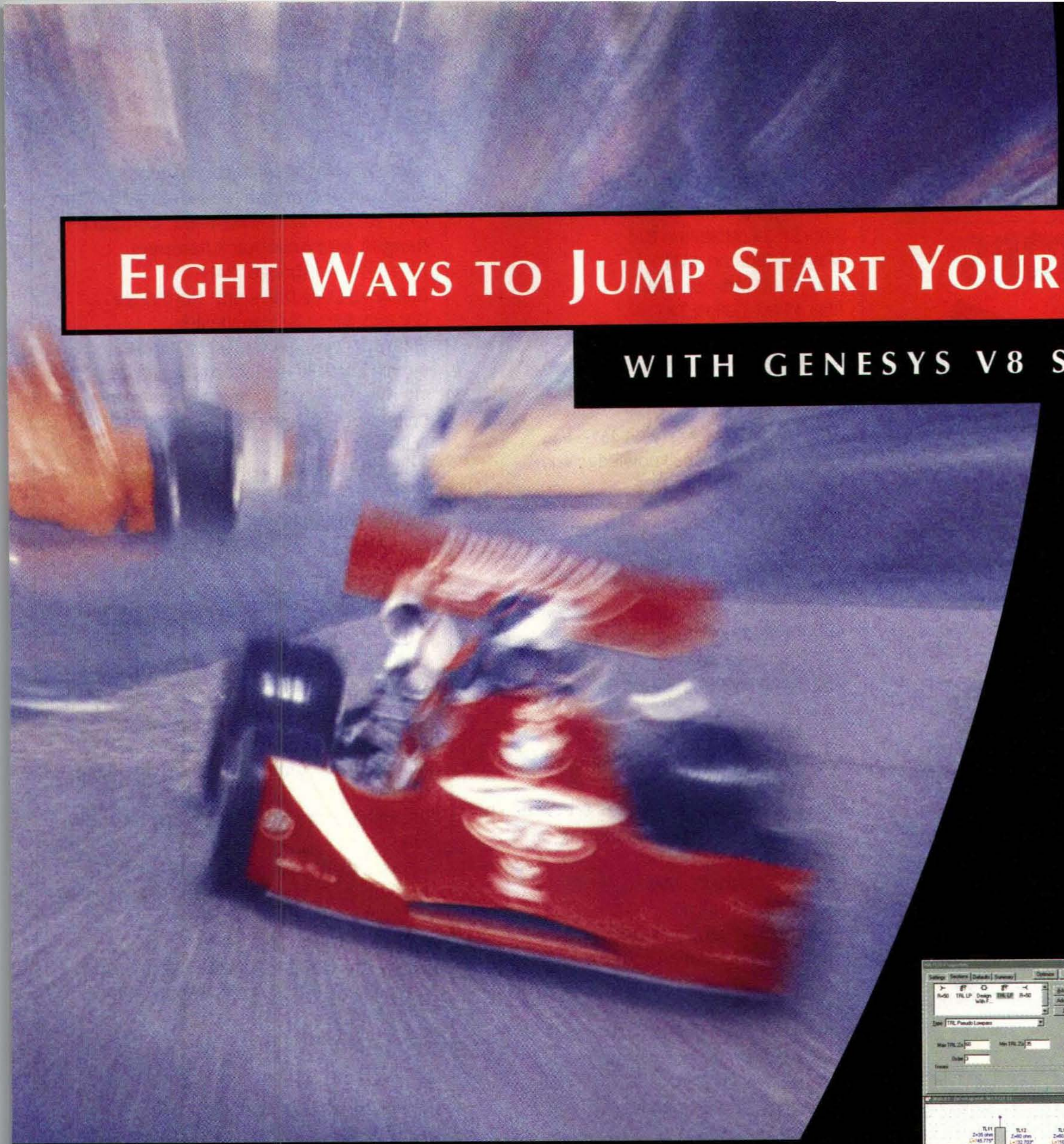
Kathrein, Inc., Scala Division—OSCAR HARRIS to regional sales manager for the Southeastern region; formerly employed with Trilogy.

Lytron—TOM EYTEL to the position of manager of customer service; formerly technical operations manager at Speedline Technologies.


EYTEL


OVERBAUGH

Calmont Wire & Cable, Inc.—PAUL OVERBAUGH to director of product/process improvement; formerly employed in the plastics-packaging industry in various engineering and production-management roles. MRF



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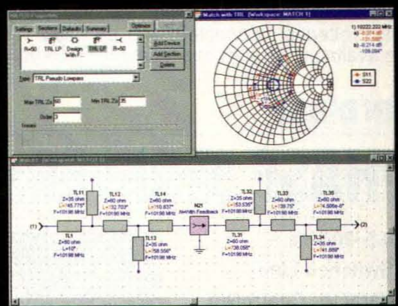

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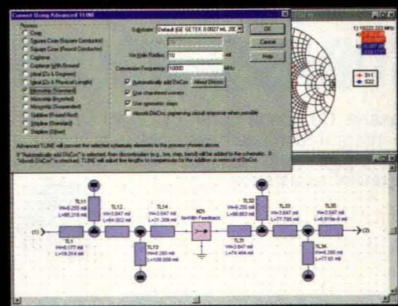

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Leaky Slot Antenna Array Suits Millimeter-Wave Applications

LEAKY-WAVE ANTENNA ARRAYS are attractive to system designers for their high directivity. Although a great deal of research has been performed on leaky-wave antenna arrays for microwave use, very little work has been done on the possibility of using this antenna architecture for millimeter-wave frequencies. For that reason, Anthony Grbic and George Elefheriades of the Edward S. Rogers Senior Department of Electrical and Computer Engineering at the University of Toronto (Toronto, Ontario, Canada) proposed a leaky-wave structure that is essentially a coplanar-waveguide (CPW) transmission line loaded with radiative, transverse series slots. The periodically loaded traveling-wave structure achieves excellent performance at 30 GHz (9.2-dB gain) with very low return loss from 26 to 36 GHz. The investigators fabricated both unidirectional and bidirectional versions of the antenna. For more information, see "Leaky CPW-Based Slot Antenna Arrays for Millimeter-Wave Applications," *IEEE Transactions on Antennas and Propagation*, November 2002, Vol. 50, No. 11, p. 1494.

Comparing Time- And Frequency-Domain Antenna Patterns

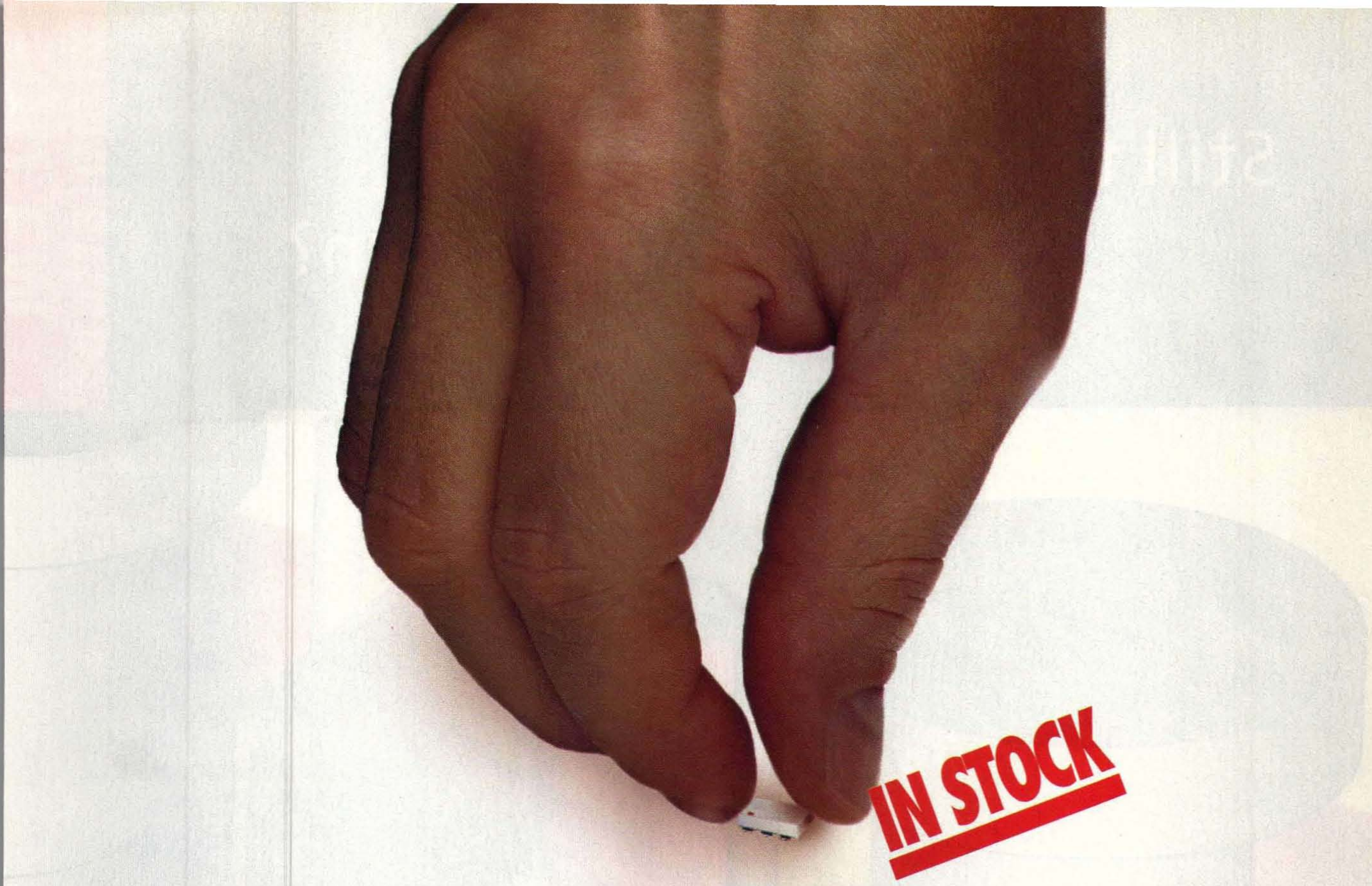
TO OVERCOME THE DIFFICULTY of modeling extremely large, space-based arrays, Leo DiDomenico of the Jet Propulsion Lab of the California Institute of Technology (Pasadena, CA) undertook a comparison of antenna patterns in both the time domain and the frequency domain. The author discovered that significant improvement in pattern analysis is possible by working with time-gated short pulses and wavelets rather than simple narrowband sinusoidal patterns. See "A Comparison of Time versus Frequency Domain Antenna Patterns," *IEEE Transactions on Antennas and Propagation*, November 2002, Vol. 50, No. 11, p. 1560.

Compact Stripline Balun Aids Balanced Bluetooth Amplifiers

COMPACT BALUNS ARE ESSENTIAL for achieving the size, cost, and performance goals of certain wireless applications, such as 2.4-GHz Bluetooth devices. The balun is important since balanced (differential) power amplifiers are often used to increase the gain and range of Bluetooth systems, and these balanced amplifiers must be connected to the largely single-ended circuitry of Bluetooth designs. By using the Microwave Office software tools from Applied Wave Research (El Segundo, CA), Shu-Chuen Loo and Kim-Fung tsang of the Department of Electrical Engineering of the City University of Hong Kong were able to perform analysis on a compact meandering stripline balun design fabricated on four-layer FR4 substrate material. As part of the balun design, a high-impedance bias line is used to provide power to the connected power amplifier. The novel balun design was compared with a half-wave transmission-line balun for identical Bluetooth power amplifiers operating from 2.4000 to 2.4835 GHz. Although the meandering-line balun showed greater amplitude imbalance (about 2 dB) than the half-wave balun, the overall performance of the meandering-line stripline balun was encouraging, with better than 0.6-dB insertion loss improvement and better than 15-dB return loss improvement when compared to the half-wave balun. The small size of the novel balun makes it ideal for size-sensitive wireless designs, such as portable Bluetooth devices. See "A Novel Compact Meandering Stripline Balun for Balanced Amplifiers With Bluetooth Application," *Microwave and Optical Technology Letters*, December 20, 2002, Vol. 35, No. 6, p. 423.

Analyzing UWB Signals In A Typical Indoor Environment

UNDERSTANDING ULTRAWIDEBAND (UWB) signal propagation will be one of the keys to the success of this pulsed "carrierless" transmission format. For that reason, Guy Schiavone and associates from the School of Electrical Engineering and Computer Science at the University of Central Florida (Orlando, FL) conducted research on UWB signal propagation in a typical indoor environment. The researchers uses the PulsON Application Demonstrator (PAD) kit (transmitter and receiver) from Time Domain Corp. in an office building where the dimensions of the test room were carefully measured for calibration. A 2-GHz bandwidth centered at 1.9 GHz was used for the measurements, which revealed some shortcomings of UWB simulations. It was found that the transmitted power must increase in an almost linear function of distance from receiver to transmitter to maintain a given bit rate. See "Analysis of Ultra-Wide Band Signal Propagation in an Indoor Environment," *Microwave and Optical Technology Letters*, January 5, 2002, Vol. 36, No. 1, p. 13.



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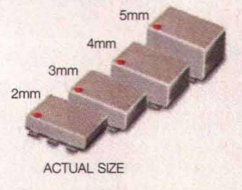

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ADE-1	+7	0.5-500	5.0	55	15	4	1.99▲
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ADE-2	+7	5-1000	6.67	47	20	3	1.99▲
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ADE-6	+7	0.05-250	4.6	40	10	5	4.95
ADEX-10	+7	10-1000	6.8	60	16	3	2.95
ADE-12	+7	50-1000	7.0	35	17	2	2.95
ADE-4	+7	200-1000	6.8	53	15	3	4.25
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ADE-1H	+17	0.5-500	5.3	52	23	4	4.95
ADE-1HW	+17	5-750	6.0	48	26	3	6.45
ADEX-10H	+17	10-1000	7.0	55	22	3	3.45
ADE-10H	+17	400-1000	7.0	39	30	3	7.95
ADE-12H	+17	500-1200	6.7	34	28	3	8.95
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3D EM Simulation

DESIGN

Meld Load-Pull Tests With EDA Tools

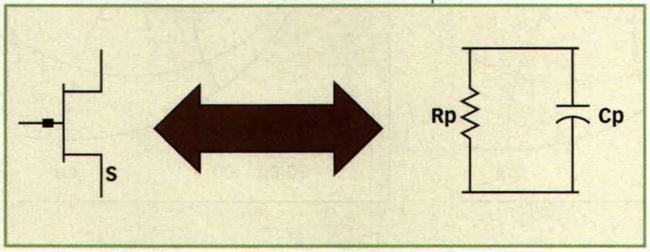
The limitations of large-signal device models can be overcome by effectively integrating load-pull measurement data into commercial EDA simulation tools.

RICHARD L. CARLSON
Distinguished Member of the Technical Staff
Motorola, Inc., Global Telecom Solutions Sector, 1303 East Algonquin Rd., Schaumburg, IL 60196; (847) 576-4144, e-mail: CRC006@motorola.com, Internet: www.motorola.com.

Power-amplifier (PA) designers are often hampered in their use of electronic-design-automation (EDA) simulation tools because of deficiencies in large-signal models. Typically, an engineer must augment EDA tools with measured data before performing a simulation. This measurement can take the form of a few data points with a manual impedance tuner or it can be a full-fledged load-pull measurement. By carefully integrating load-pull measurements with EDA tools, it is possible to overcome the limitations of current large-signal device models and improve the overall process of designing PAs.

The load-pull measurement process is, of course, a method of applying known load states (impedances) to a RF power device and measuring pertinent performance attributes (i.e., power-out, efficiency, linearity, and input impedance). As parameters, such as frequency, drive power, supply voltage, and quiescent current, are swept during the measurements, the complexity and time required for the measurements grow geometrically. Such swept load-pull measurements extend the design-cycle time because physical prototypes and measurements must be made to fill in the missing pieces for the EDA tools.

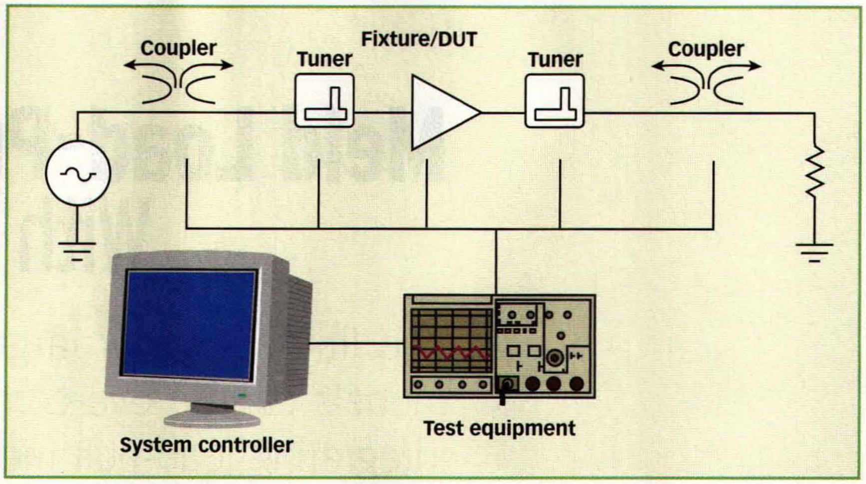
It is also not trivial to apply the load-pull data to an EDA tool. Typically, designers must translate data from the load-pull measurement domain to the simulation framework. Connecting the two environments generally involves selecting impedance "points" from either contours or tabular data from the measurement side and manually entering them into the simulation tool. This manual approach is suitable for a design with narrow performance criteria, but is unrealistic when multiple attributes (power out, efficiency, and linearity over bandwidth, drive-power, and bias settings) are considered. Poor integration of load-pull data with EDA circuit-simulation tools is a major deficiency in the RF power design process. Designers require compre-



1. An unmatched power transistor operating below resonance can be approximately represented by this equivalent circuit.

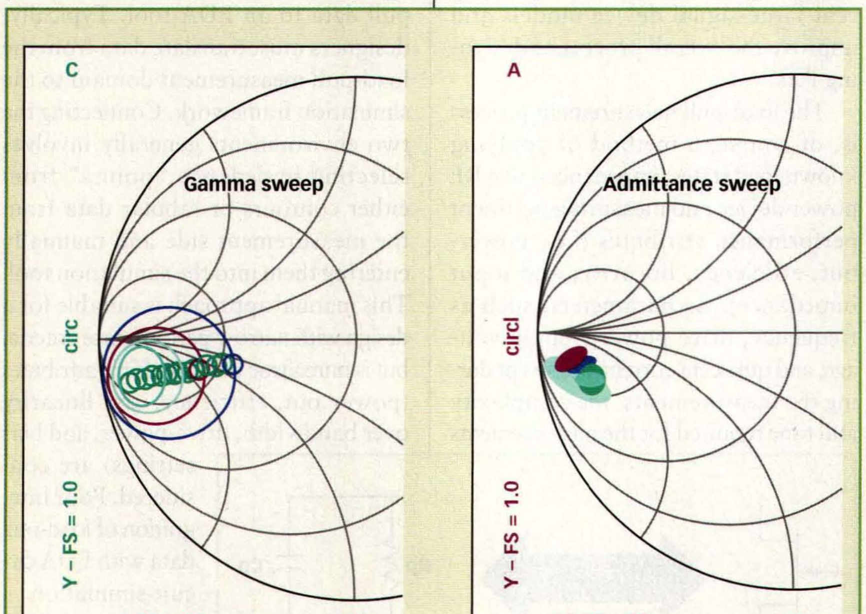
hensive load-pull information (both dependent and independent variables) in their EDA tools. They want an effective RF power model that can be implemented into their simulation just like any other component model.

Major EDA tool and measurement system vendors are beginning to recognize the value of integrating load-pull data with modeling. Applied Wave Research (El Segundo, CA) introduced a load-pull wizard in their circuit simulator, Microwave Office 2002.[1] This capability facilitates viewing load-pull data and establishing load-pull simulations with device models. It also allows data files from commercial measurement systems to be integrated to the simulator versus load only. However, frequency, drive-power, and bias are fixed values making it difficult to assess performance over bandwidth or other operating parameters. The Advanced Design System (ADS) from Agilent Technologies (Santa Rosa, CA) provides the ability to generate behavioral models for simulation speed enhancements using the Load-pullSetup and AmpLoad-pull elements,[2] but these capabilities do not address the deficiencies of the high-power device models. Recently, Agilent has announced the ability to import load-pull measurements in ADS2003.



3. This system performs load-pull device measurements under computer control.

On the hardware side, Maury Microwave (Ontario, CA) markets a translator converting load-pull files to Agilent ADS.[3] Little information is available, however, on the dimensionality of the data or on linking these data to the simulator. Focus Microwaves (Dollard-des-Oreamux, Quebec, Canada) offers the µW-PADS[4] and WinPADS[5] software that use contours to drive circuit-matching networks using proprietary software. These programs employ a limited set of lumped- and distributed-circuit elements that may be optimized based on load-pull measurements; unfortunately, the platform is a non-mainstream EDA environment specializing only in PA design.



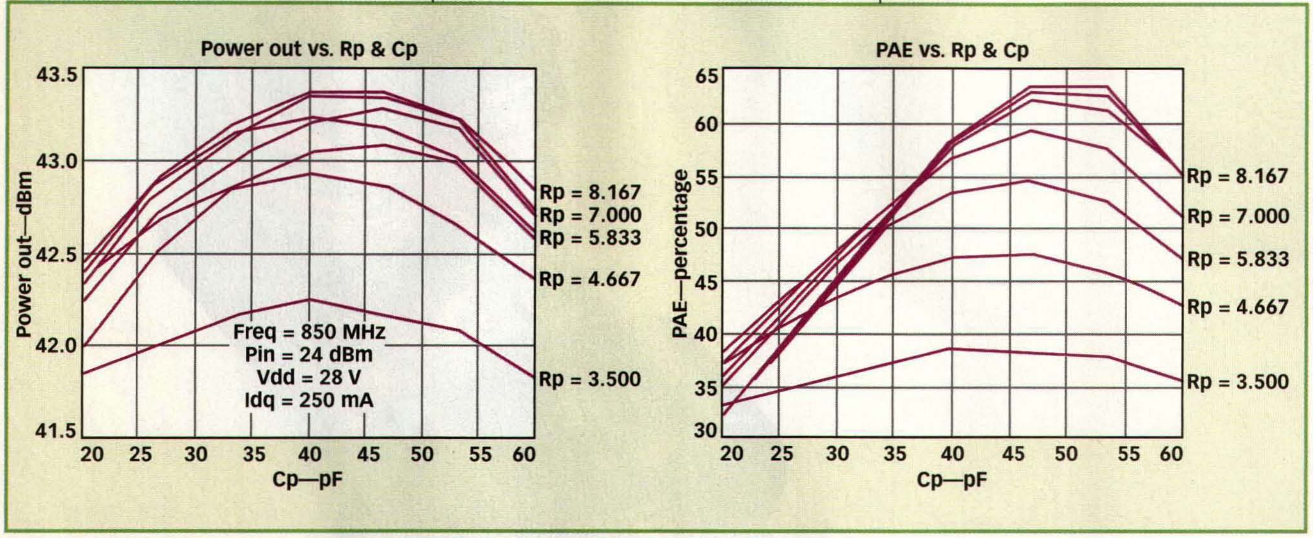
2. The gamma (Γ) and modified admittance sweep (right) methods are compared here.

Engineers within the Global Telecom Solutions Sector (GTSS) infrastructure equipment group of Motorola (SBCL—Schaumburg, IL) have long recognized the chasm between load-pull measurements and simulation tools. In the mid-1990s, a program was initiated to bridge the load-pull/simulation gap. A primary tenet of this program was to merge and analyze load-pull measurements within mainstream EDA tools. A load-pull measurement system was used to measure device data, not extensively analyze it. Data reduction was reserved for the EDA simulation domain through the use of network analysis and optimization. This vision was realized by:

1. Extracting accurate load-pull data over a wide operating space including frequency, drive-power, bias, and load.
2. Integrating this entire measurement space into a database accessible to EDA design tools.
3. Developing simulation utilities to design RF PAs exploiting load-pull measurements.

The first two tasks are intertwined. Unfortunately, commercial load-pull systems have been unable to provide the multidimensional sweep in a format compliant with the EDA tools. In the

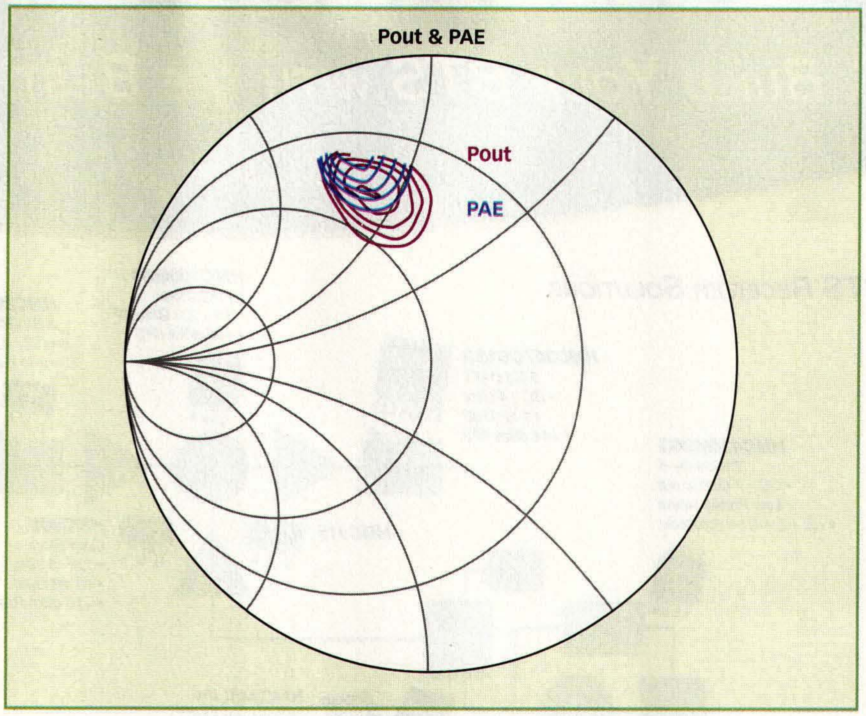
past, curve-fitting was applied to the data to achieve EDA tool compliance. However, with the addition of independent variables, curve-fitting becomes untenable. Motorola's solution, therefore, was to acquire commercial load-pull hardware and internally develop custom control software. Focus Microwaves supplied tuner hardware and provided the software-calls into the tuner hardware. Load-pull control software was written in Labview™ software from National Instruments (Austin, TX). These tools allowed the development of a semicustom system using professional-



4. The ADS software was used to display load-pull measured device output power (left) and power-added efficiency (right) as functions of the resistive-capacitive load R_pC_p.

grade tuner hardware. Control of the sweep algorithms also assured that the resultant data structure was EDA compliant without the intermediate data conditioning.

Measurements from the control software permitted the construction of a database of load-pull information. This database was built so that multiple analysis tools could access the measurements within it. The primary application of the data was in EDA circuit-simulation tools, and specifically ADS. ADS utilities were developed to exploit the data. Design utilities included the ability to optimize matching networks driven by high-level performance goals such as power-out, linearity, efficiency, and input match using advanced optimizers in circuit-simulation tools. The salient features of this custom load-pull system will be presented. This report will also show how this data can be electronically ported and uti-



5. The ADS software was also used to generate this device output-power and power-added-efficiency contour plot.

lized in an EDA circuit-simulation tool to design RF PAs. Examples will be provided using load-pull data of an MRF9045M (a 45-W output-power transistor) in the 700-to-1000-MHz band.

Load-pull measurements provide performance metrics (PM) on a device under numerous stimulus states. For RF power characterization, PMs are power-out, efficiency, linearity, and input impedance and are dependent variables in the system. Swept independent variables are frequency, complex load, supply-voltage, bias-current, and drive-power. Equation 1 shows the basic formulation for a comprehensive set of load-pull information:

$$PM \propto f\{freq, \Gamma, Vdd, Id, Pin\} \quad (1)$$

(Swept input-image impedance, source-pull, may be implemented, but is not considered here. Harmonic terminations are not presently supported in this system. Both input-image impedance and harmonic terminations have secondary effects on their PMs.) Complex load, Γ, can be decomposed into two scalars yielding six independent variables that must be swept in a methodical fashion. Commercial systems normally sweep the load reflection coefficient, Γ, in polar coordinates. This sweep is usually in the form of:

$$\Gamma_{load} = \Gamma_{offset} + |\Gamma_s| \angle\theta_s \quad (2)$$

where:

Γ_{load} = the reflection coefficient presented to the device under test (DUT),
Γ_{offset} = a constant complex number,
$|\Gamma_s|$ = the swept magnitude, and
θ_s = the swept angle.

Graphically, this expression is a series of concentric circles with a fixed offset from the center of the Smith Chart. Over a narrow band, this specification may be adequate. However, over a wide band the Γ_{offset} should change over frequency to keep the load at or near the peak performance region requiring that Γ_{offset} be swept also. Since the Γ_{load} specification method is not very insightful and the addition of a third swept variable is complicating, a new, more intuitive method of specifying the load is needed.

Small-signal S-parameter measurements may be used to construct an equivalent circuit for the output of a power device. Converting the S-parameters to an equivalent parallel network reveals that the output load behaves as an admittance with fairly static values for conductance and capacitance (an unmatched device operating below resonance). This model makes intuitive sense from a physical perspective. The real part of the admittance represents

FET resistance R_{ds} while multiple drain (collector) cells formulate a shunt capacitance. An unmatched LDMOS device, for example, appears to be well represented by a parallel R_p and C_p model. Equation 3 shows the admittance formula for a parallel R_pC_p network while **Fig. 1** shows this trivial circuit:

SEE EQ. 3 IN BOX AT RIGHT

Instead of sweeping of Γ, a more effective approach may involve sweeping the constituent admittance components (R_p and C_p) presented at the device lead plane. The next step is to determine how to establish these sweep values.

PA output networks are generally not conjugate-matched systems for the real part of the load. Typically, the desired power output and available supply voltage determine the real part of the load presented to the device, not the device impedance. Equation 4 shows the classical approximation for the real part of the load:

SEE EQ. 4 IN BOX AT RIGHT

where:

V_{dd} = the supply voltage,

V_{sat} = the device saturation voltage, and

P_{out} = the peak output power.

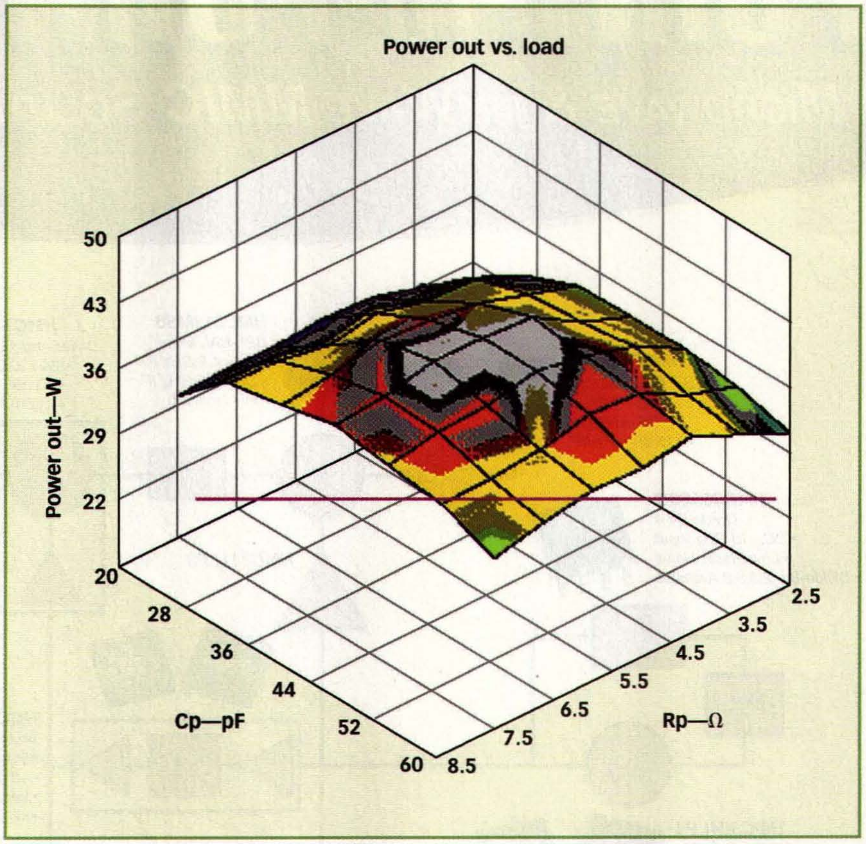
RF power designers will recognize this equation as an estimate of the required parallel resistive load to achieve output power for a given supply voltage, V_{dd}. This equation is insightful because of its familiarity and the way it links the real part of the load to actual measurement system terminal parameters. Therefore, the real part of the load will be swept about R_p as defined by Eq. 4.

$$Ydevice = \frac{G + j \times B = 1}{Rp + j\omega C} \quad (3)$$

$$Rp = \frac{\left((V_{dd} - V_{sat})\hat{}2\right)}{(2 \times P_{out})} \quad (4)$$

$$PM \propto f\{freq,\ Rp,\ Cp,\ Vdd,\ Id,\ Pin\} \quad (5)$$

Conjugate matching is used to define the imaginary part of the load. As Fig. 1 shows, a capacitive susceptance is seen looking into the device. Therefore, to achieve a conjugate match, a negative capacitance, C_p, is the desired swept parameter. This admittance formulation intrinsically provides frequency compensation through the Ω scalar. Load-pull measurements are center tuned over a much wider frequency range than when using the fre-



6. The HiQ software from National Instruments was used to create this three-dimensional (3D) plot of device output power as a function of load.

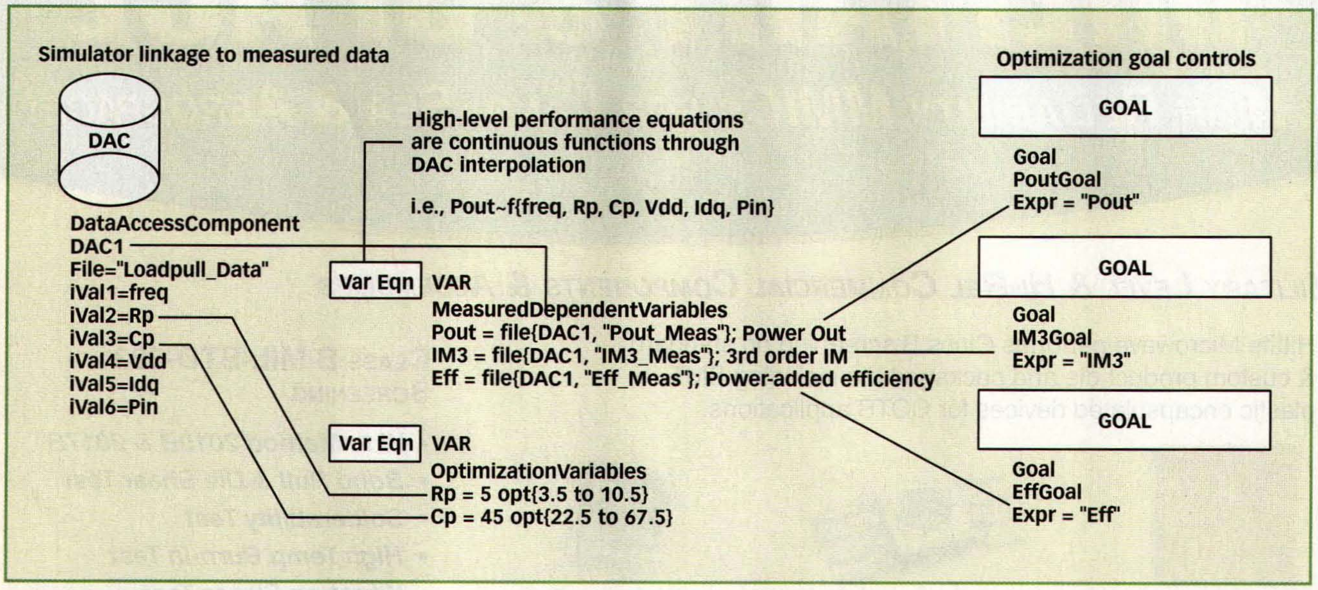
quency-independent γ formulation. The R_pC_p sweep produces meaningful data points, not the far out of bound points produced by the Γ at some states. This minimizes useless data and speeds up the measurement process. Additionally, this load viewpoint is comprised of familiar circuit elements that are easy to understand in physical significance. As a result, Eq. 1 can be rewritten as:

SEE EQ. 5 IN BOX ON P. 60

This is the sweep and order method used in the Motorola load-pull system. This is also the equation that will be linked to the EDA tools described later. (This load formulation can be generalized for nonconstant R_p and C_p in the case of an internally matched device or where package parasitic elements are influential.). **Figure 2** compares the Γ and admittance sweep differences on the Smith Chart. Parameter R_pC_p is swept across the constant conductance circles in sectors on the chart. The center of the cluster naturally shifts as frequency changes.

Figure 3 shows a generic block diagram of the measurement system. It consists of directional couplers, input/output (I/O) electromechanical tuners, test equipment, and a computer controller with GPIB bus. The fixture-device under test (DUT) includes the transistor and input and output fixture circuits. Typically, these fixture circuits perform a section of prematching since the device I/O impedances are extremely low.

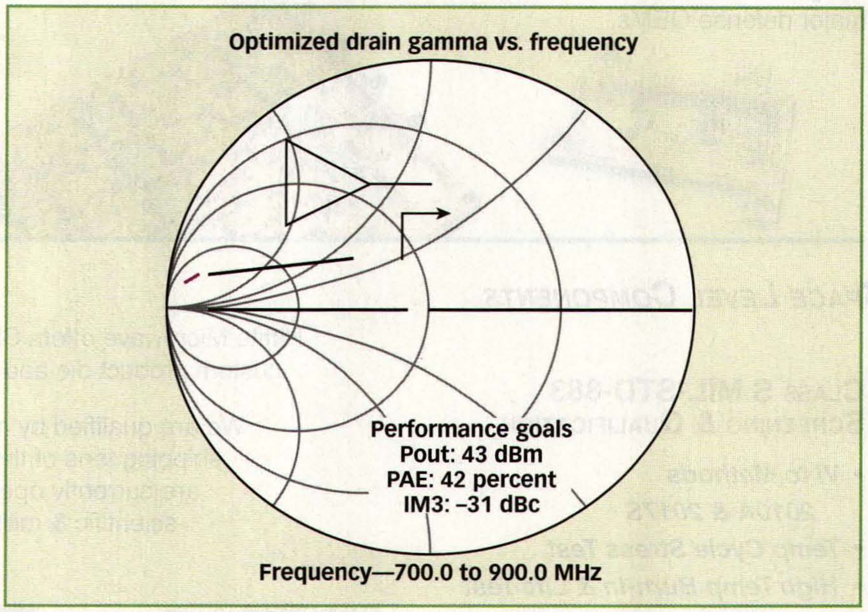
Measurements are referenced at the device lead plane including the performance and the swept independent variables. To accomplish this, circuitry leading to/from the device lead plane to the respective directional coupler is carefully characterized prior to load-pull measurements. Two-port tuner S-parameters are read and interpolated at each load state. The fully characterized system permits de-embedded measurements at the device lead plane. Power-



7. This ADS schematic excerpt illustrates the optimization setup to extract impedance at specified output-power, efficiency, and third-order-intercept points.

in is also referenced at the lead plane. At each test state in the six dimensional sweep, the input tuner is set to achieve a conjugate match (or as desired if applying source-pull) at the input-tuner-fixture/DUT plane. Device input impedance is then calculated since a calibrated vector network analyzer (VNA) is part of the test equipment. With the knowledge of the device input impedance, system input losses are calculated and the drive signal is compensated to overcome tuner and matching losses. Thus, the drive power independent variable is referenced at the device plane and independent of the dynamic circuit losses (which can be substantial for low impedance devices). De-embedding is also required on the output side to set the tuner. The R_PC_P load is referenced at the device plane and therefore the output tuner Γ is calculated to provide these known loads back at the device plane. Eliminating all fixture dependencies is critical when the goal is to capture device performance only.

The measurement system is capable of reading power-out, current drain, linearity, and input impedance. Efficiency can be calculated from these measurements and the independent variables. The test-signal source (a dual arbitrary signal generator) can produce



8. Extracted impedance loci were taken from 700 to 900 MHz for the performance goals noted.

CW, two-tone, or complex modulation waveforms. A vector signal analyzer can assess linearity in terms of intermodulation distortion (IMD) or adjacent-channel coupled power ratio (ACCPR). Once a load-pull measurement is completed over the six independent variables, test data are stored in a database where they can be extracted by multiple analysis software such as visualization tools or circuit simulators.

Hewlett-Packard Co. (now Agilent Technologies) developed the CITIfile (Common Instrumentation Transfer and Interchange) format for computer/instrumentation data exchange and subsequently adopted it to the MDS and ADS EDA tools. CITIfile is suited for load-pull data since it can support an arbitrary number of dependent and independent variables. One requirement is that the independent variables must be methodically swept—that is, the same inner values of the sweep must be

identical. In the measurement system presented here, the order of the independent variables is frequency, R_p, C_p, supply voltage, bias current, and drive-power. Thus, for each frequency, the five independent variables below it must take on the same values to be CITIfile compliant. (The frequency tracking benefit of the R_pC_p load descriptor becomes clear.) Before the development of the present measurement system, load-pull CITIfiles were built by curve-fitting measurements. Curve-fitting added an additional step, which became very difficult to implement with additional independent variables. The customized measurement system is compatible with CITIfile by system design, and therefore no intermediate mathematical manipulation is required. The measurement system automatically places the load-pull data in a tool independent database. When a designer requires access to the load-pull data for the circuit simulation, a custom Labview utility is executed allowing perusal of the database. The utility allows the user to select the pertinent operating space and constructs a CITIfile about those terminal conditions. Next, the CITIfile must be linked to the EDA environment.

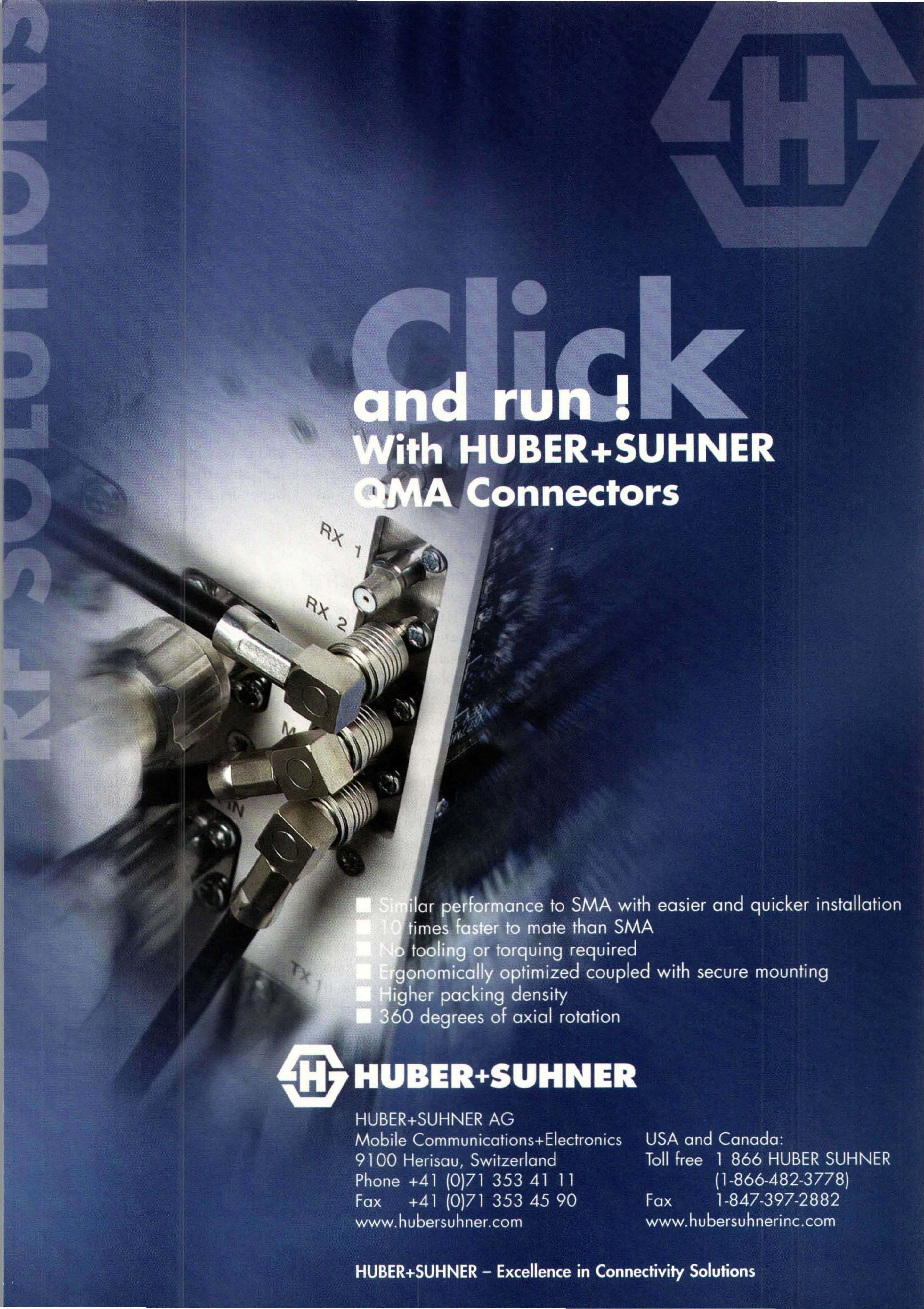
Agilent EDA tools support the concept of a DATASET object. This object holds either simulation information or data imported from the outside (such as the case here). The DATASET has the ability to read a CITIfile through appropriate menu selections in the respective tool. Once a CITIfile has been read into the DATASET, load-pull data is linked into the EDA environment and measurements may be viewed by ADS data display. However, one more step is required to link the data to the simulator. In the schematic environment, a special component called the DataAccessComponet (DAC) must be instantiated on the schematic to permit the simulator to process the data. The DAC (or DATASETVARIABLE in MDS) points to the file containing the measured data, makes the dependent and independent variables accessible to the simulator, and can support up to ten independent variables. In essence, the DAC implements Eq. 5 in the simulation. The DAC is more than just a lookup table; it has the ability to interpolate between independent variables. Interpolation enables optimizations providing continuity to the dependent data. Details on optimization will be covered later.

ADS has the capability to graphically display load-pull data directly from the measurement system without passing through the simulator. Many different graphical cross-sections can be displayed since Eq. 5 is a six-dimensional relationship. Several data display graphics will be presented as examples of analyzing the measurements. The examples shown here are based on a Motorola MRF9045M LDMOS device operating at its rated 45-W out-

Agilent EDA tools support the concept of a DATASET object. This object holds either simulation information or data imported from the outside.

put-power level in the 700-to-1000-MHz range.

Power out and efficiency versus load are shown in Figs. 4a and 4b. Performance variations are plotted against two independent variables represented by the equivalent parallel R_pC_p presented to the device output. The capacitance sweep (C_p) is shown on the x-axis while the multiple traces show variations in parallel resistance (R_p). Essentially, the plots depict Eq. 5 with R_p and C_p set as the swept ordinates (wildcards) and the other four variables fixed. Figure 4 shows, for example, that the peak power occurs at approximately 45 pF and 8.5 Ω. Efficiency peaks at a slightly larger capacitance, approximately 50 pF. If other frequencies were plotted in this format, it would be seen that the peaks remain relatively constant at these capacitance values for the respective parameters, lending credibility to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the R_pC_p sweep method. Linearity and gain can be plotted similarly while complex device input Γ can be displayed on the Smith Chart. Concurrently generating these plots enables viewing all pertinent performance metrics versus load. Plots versus the other independent variables can also be displayed by fixing the load wildcards and enabling the sweep of other terminal variables. For example, drive-up performance or frequency dependencies can easily be viewed by making them the wildcard variable in the graph. A further enhancement is to add "slider controls" to the other variables to vary the values in those dimensions. **Figure 5** shows that contours can be displayed using the ADS built-in polar contour function. **Figure 6** illustrates a three-dimensional (3D) power-out versus load plot where the data have been imported into a mathematical analysis package (the HiQ™ package from National Instruments). Visualization may be accomplished by sweeping a third independent variable (such as power-in) to create an animation. Clearly, the simulation tool and other mathematical packages enable the designer to present and analyze the raw measured data equivalent or superior to the commercial measurement systems. Data presentation, however, is just an initial step in using the measurements for designing PAs.

***Linking** measurements to a circuit simulator creates powerful design opportunities.*

Linking measurements to a circuit simulator creates powerful design opportunities. By employing a simulator, the data can be further reduced to insightful information and utilized for PA circuit design. One analysis approach is to employ an optimizer to search for specific performance conditions. For example, suppose it is desired to find the impedance locus that conform to concurrent power-out, efficiency, and linearity goals versus frequency. An optimization can be established to perform this task using the circuit simulator. **Figure 7** is a schematic excerpt showing how three variable equations (output power, third-order intercept, and efficiency) and goal statements are established in ADS. Variable expressions are linked to the goal control blocks as well as the DAC, which provides association to the measured data. During each iteration, the DAC reads and interpolates the performance values based on the present independent variable values. In this case, R_p and C_p independent variables (representing the load) are allowed to vary in the optimization (for simplicity, assume the other independent variables are fixed). When properly configured, the goals, equations and DAC will establish an error function. Since the DAC can interpolate the dependent variables, the equations behave as continuous functions. The optimizer therefore drives the R_p and C_p values continuously until an error function minimum is achieved.

The complexity of the example can be expanded by allowing the other independent variables to vary in the optimization (and allowed to take on different values at different frequencies). These other independent variables can also be plotted versus frequency.

Figure 8 shows the impedance locus presented to the output required to meet the three performance criteria based on an optimization. In this optimization, the drive-power and bias current were also allowed to vary; however the supply voltage was held constant. These other independent parameters also can be plotted along with the high-level responses after optimization. This optimization could be further tailored to weight each different performance goal differently or attach more importance to specific parts of the band. A further embellishment is to parameter sweep the goal specifications resulting in a family of gamma plots. The analysis described here might be one of the first steps a user would perform in the EDA simulation environment to understand the target


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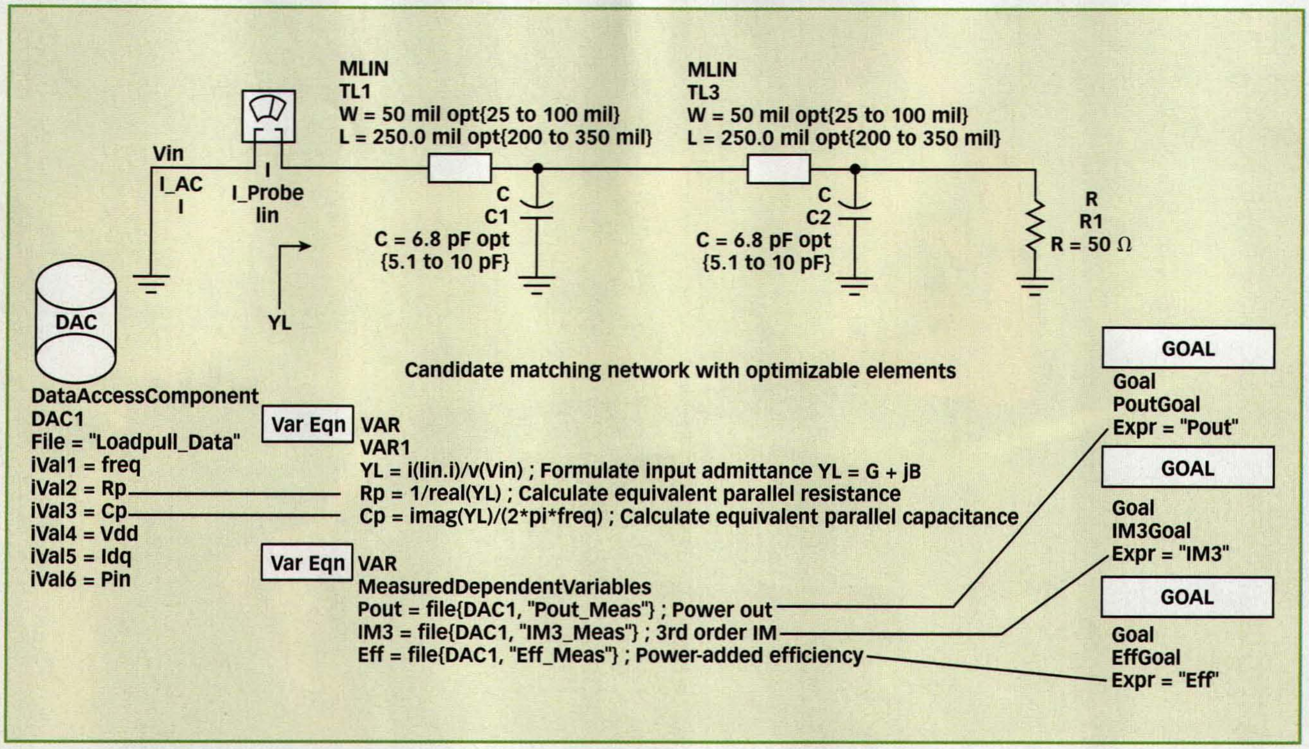

9. This ADS schematic excerpt illustrates a generic matching network optimization setup.

impedances the output matching network must achieve. The next step would be to design and optimize an output network using this response as a target.

Previous analysis provided the output load to achieve the specified performance goals. A network must be designed that closely mimics this response. In the traditional disconnected process, the impedance locus would be the only data the designer has available within the simulation environment—providing he was skilled enough to have hand selected the best points from contours or tabular data. With the system described here, however, the full load-pull space including impedance with corresponding performance is available. Using Fig. 8 as a guide, an initial topology and component values are chosen usually through the Smith Chart or matching synthesis program. Once the topology and values are established, a circuit optimization is conducted with the element values driven by performance specifications, not abstract impedances. Contrast this new method with the traditional approach where only a handful of select states are available. With prior methods, EDA optimization goals are strictly impedance based where the designer attempts to optimize for the best match. No insight is provided on high-level performance—a problem when the optimized response is not identical to the selected values. The new method with the multidimensional load-pull space integrated in the EDA simulator takes a different

High-level performance metrics and their corresponding impedances are accessible to the simulator and enable the designer to establish network optimization using these high-level specifications as goal drivers.

approach to optimization.

High-level performance metrics and their corresponding impedances are accessible to the simulator and enable the designer to establish network optimization using these high-level specifications as goal drivers. As illustrated in **Fig. 9**, this is accomplished by driving the candidate output matching network with an AC source and utilizing voltage and current probes formulating an admittance calculation looking into the candidate network. Through the auxiliary equations, the driving-point admittance is converted to equivalent R_pC_p. Values of R_p and C_p are then linked into the DAC element; steering the value of the high-level performance metrics. The optimization process is iterative and an error function based on the goal blocks is calculated after each iteration and drive tunable circuit element values. Circuit-element changes affect driving point admittance and close the optimization loop. At the conclusion of the optimization, an impedance response, performance responses, and optimized circuit-element values are available. Network optimization is based on high-level performance goals. Furthermore, the optimization used the full space of load-pull data to arrive at a solution—not a group of heuristically selected points. The results of a sample optimization are shown in **Fig. 10.**

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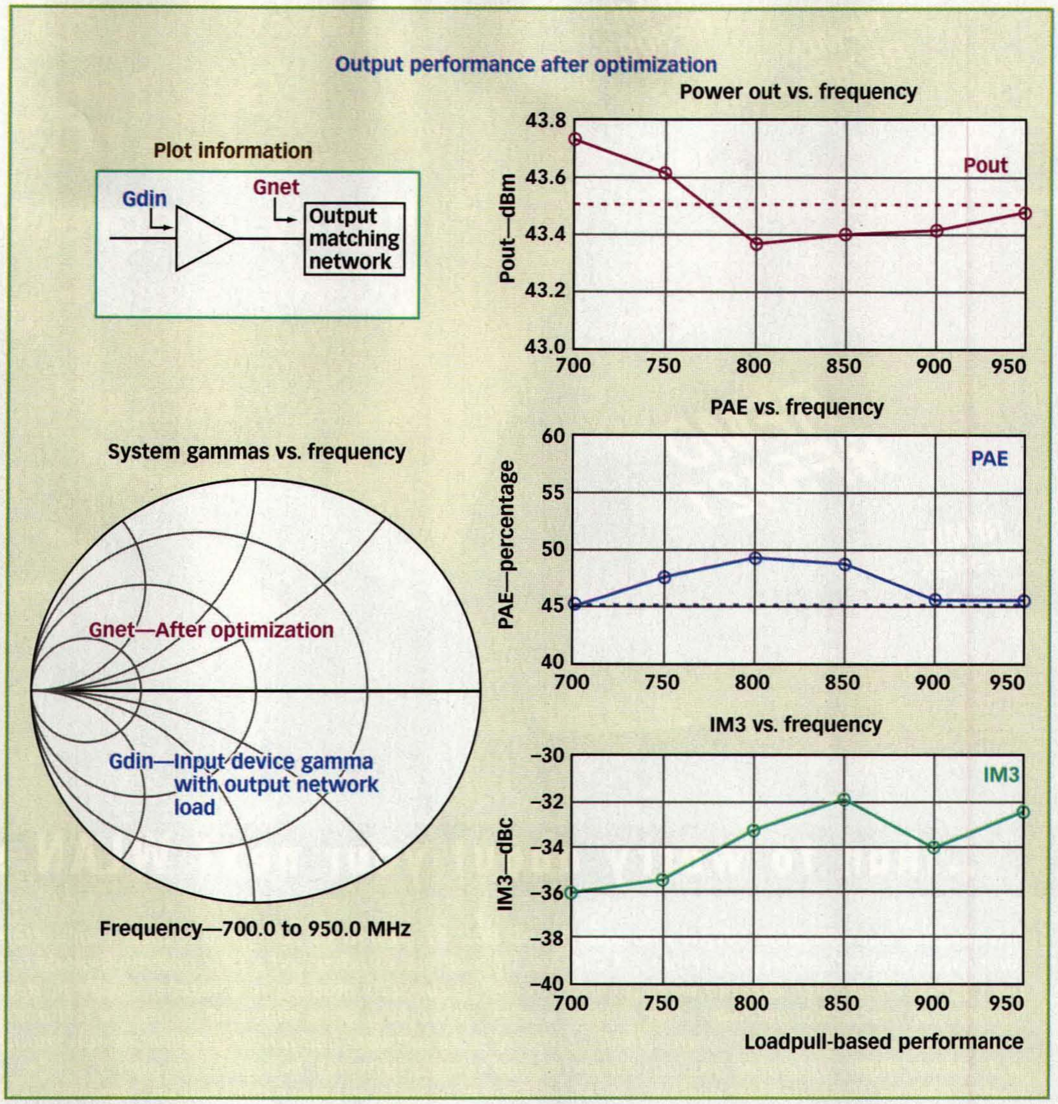
along a number of avenues at this point. A statistical Monte Carlo run can be established by allowing the circuit elements to vary and observing histograms of high-level performance. The input match can be designed using similar optimization techniques since the device input impedance is a dependent load-pull variable. Once the I/O matches are designed, a module drive-up performance is possible referencing the load-pull data. Integrating the load-pull measurements into the EDA simulation environment clearly opens up new, cycle-time-saving simulation possibilities.



10. These performance levels result following the output-network circuit optimization for the Motorola MRF9045M power transistor.

The RF power designer now has a more comprehensive toolbox at his disposal. Linkage of a load-pull database to a circuit simulator effectively creates a behavioral model. The model can be instantiated into the EDA environment just like any other primitive model and enables rapid up-front architectural decisions leading to circuit and module designs. The EDA utilities discussed here are just a few of the design steps in the development process flow. Small signal s-parameters over multiple bias conditions can be added to the library database. With these large and small signal data, the entire PA design flow can be implemented into a "Design Guide." The design guide concept is a series of development steps required to design a specific application (i.e., a PA). When an ADS customized design guide is created, these steps become sequential pull-down menu selections integrated into the design environment. This promotes design consistency and eliminates much of the tedium in setting up, formatting, and presenting simulation information. It also provides a consistent interface that can be easily archived and navigated for reuse opportunities. MRF

REFERENCES

1. "What's New in 2002?" Applied Wave Research, El Segundo, CA, www.mwoffice.com.

2. "Advanced Design System 2002 Circuit Component Systems Models," Agilent Technologies Manual Set, February 2002, p. 296, www.agilent.com.

3. "Precision Microwave Instruments and Components Catalog," Maury Microwave Corp., Ontario, CA, 2001, p. 64, www.maurymw.com.

4. "The CCMT-μW-PADS Work Station," Technical Note 1-93, Focus Microwaves, Inc., Dollard-des-Oreamux, Quebec, Canada, www.focus-microwaves.com.

5. "WinPADS, A Power Amplifier Design Software Using Load-Pull Contours," Product Note 56, Focus Microwaves, Inc., Dollard-des-Oreamux, Quebec, Canada, www.focus-microwaves.com.

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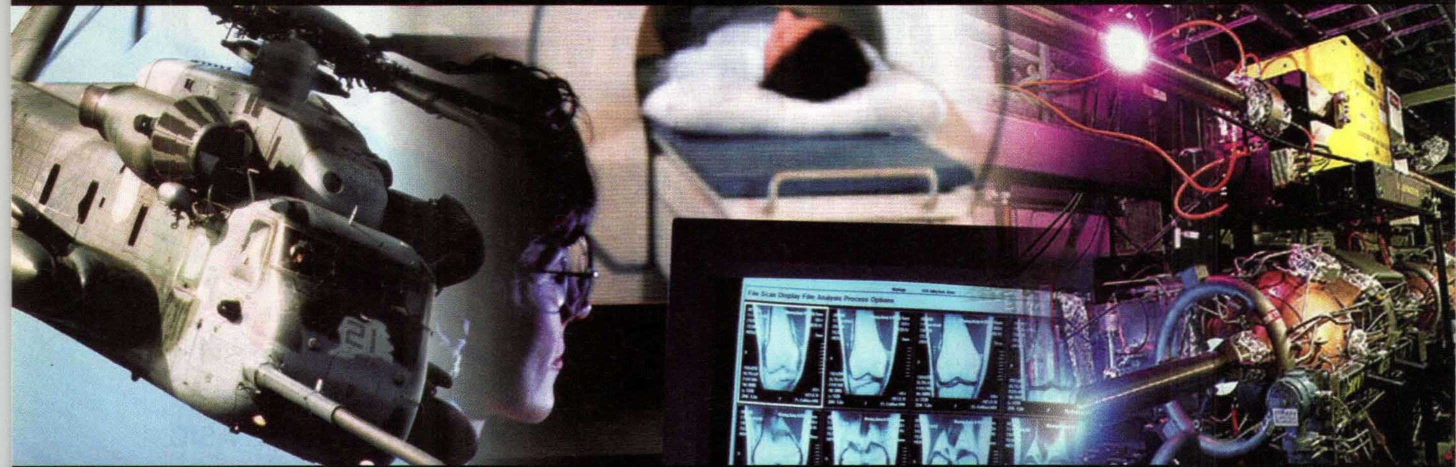

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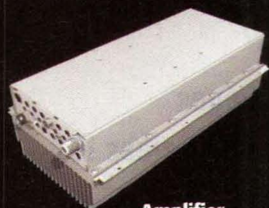

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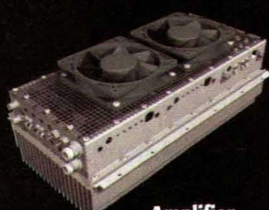

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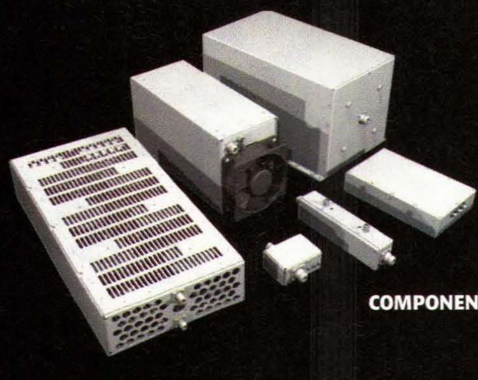

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DESIGN

Reducing ESR Measurement Errors

A variety of different measurement techniques can be used to evaluate the equivalent series resistance (ESR) of high-frequency capacitors and inductors, with varying results.

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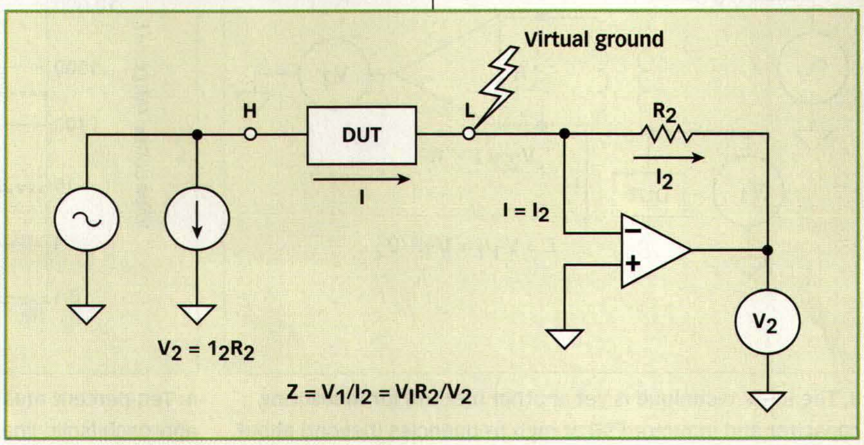
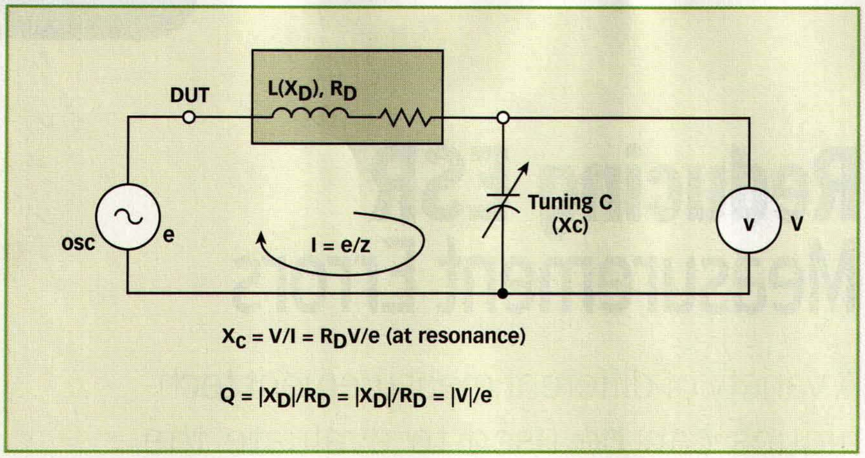
Capacitor and inductor improvements have resulted in lower equivalent-series-resistance (ESR) values for these circuit elements. In turn, measurements of ESR for capacitors and inductors have become even more difficult. ESR measurements errors are caused either by the minimum (or absolute value) of the ESR or the phase of the complex signal vector, both of which can present very significant measurement challenges. While error-correction techniques can be used to minimize them, at some point the limitations of physics limit their feasibility. Understanding measurement-technique limitations, frequency dependencies, and fixture-error correction can greatly help the designer apply the proper processes to get the best possible results.

Several techniques are used to measure ESR. The best approach for a given situation depends primarily on the measurement frequency. Resonant techniques or the autobalancing bridge are used for low-frequency measurements, while the resonant method using a cavity, a reflection test set with a vector network analyzer (VNA) or the RF current-voltage (I-V) method with dedicated impedance measuring equipment are used for high-frequency measurements.

For low-frequency measurements, the autobalancing bridge measurement technique **(Fig. 1)** includes an AC source to supply current through a device under test (DUT). The voltage across the DUT is measured by V1 and the current



1. This diagram illustrates the autobalancing bridge-measurement technique.



2. This simple diagram shows the resonant measurement technique for evaluating capacitor and inductor ESR.

through the DUT is derived from V2/R2. It is important to remember that V1 and V2 are vector voltmeters, which means that they measure both the magnitude and phase of the AC signal. To achieve this, they actually measure the magnitude of the signal at 0 deg. (representing the real part) and the magnitude of the signal at 90 deg. (for the imaginary part). These measurements are made using mixers with very high dynamic ranges.

Although the real part will represent the ESR value of the DUT, most low-ESR components also have a relatively high reactive part. The ratio of the two is called the quality factor, Q (or inversely D or tan δ, and is the ratio of the imaginary to real parts. Since ceramic capacitors with Q over 10,000 are quite common, the mixer must attempt to separate the real portion (ESR) in the presence of a very large input signal that is almost entirely reactive, which is a significant challenge.

Most impedance measurement techniques use some form of vector separation. This inherently limits the accuracy of very low ESR measurements. Recent advances have been made in mixer design and new instrumentation that allow measurements of even-lower ESR values to be measured by the autobalancing bridge technique.

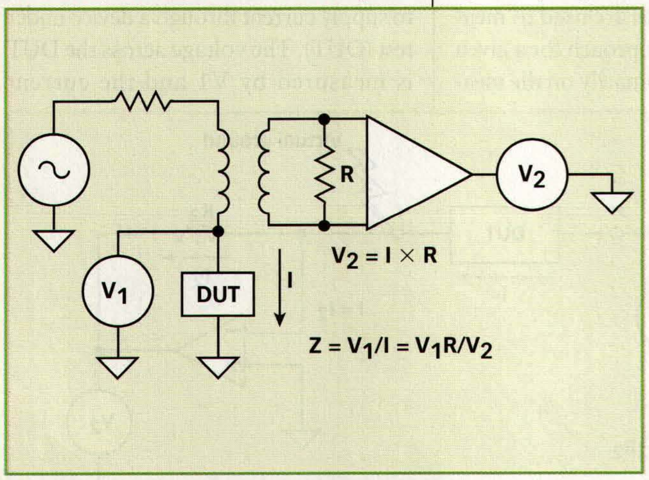
However, another method called the resonant technique does not rely on vector separation, and has been used for many years in the form of the Q-meter **(Fig. 2)**. Although this technique is cumbersome, it can provide the most accurate Q measurement results when the Q is very high (more than 10,000), as long as extreme care is taken in performing the measurement.

For high-frequency ESR measurements, Q-meters usually operate up to the tens of megahertz, and autobalancing bridge technology now allows measurements to 110 MHz. However, in many cases, ESR must be measured at higher frequencies where three techniques—the RF-IV technique with dedicated impedance measuring equipment, the resonant technique using a cavity, and the reflection test set with network analyzer—are available.

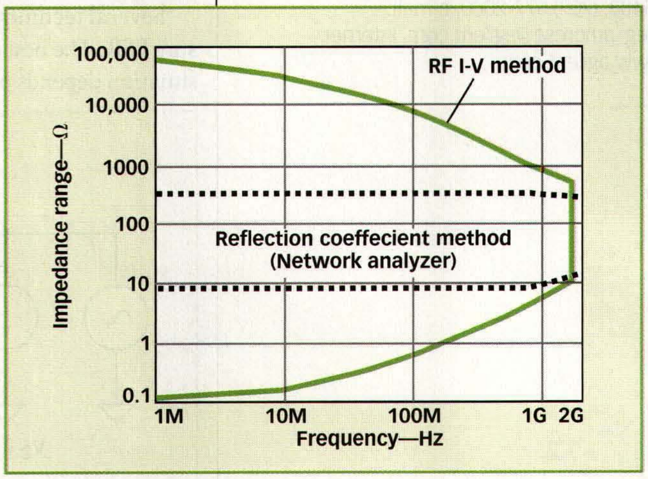
The RF-IV technique **(Fig. 3)** is very different from the autobalancing bridge approach, although it appears quite similar according to the simple schematic. Both methods require two vector voltmeters: one for current and one for voltage, each of which has the same basic operating principles and consequently the same limitations as when used in low-frequency ESR measurements. The technique that employs a VNA and reflection test set does not work well for very low or very high impedances and results in very large ESR measurement errors. **Figure 4** offers a comparison of the RF-IV (solid-line) and VNA (dotted-line) methods.

Calibration Standards

All measurements will have error caused by the quality and traceability of the calibration standards as well as the pro-



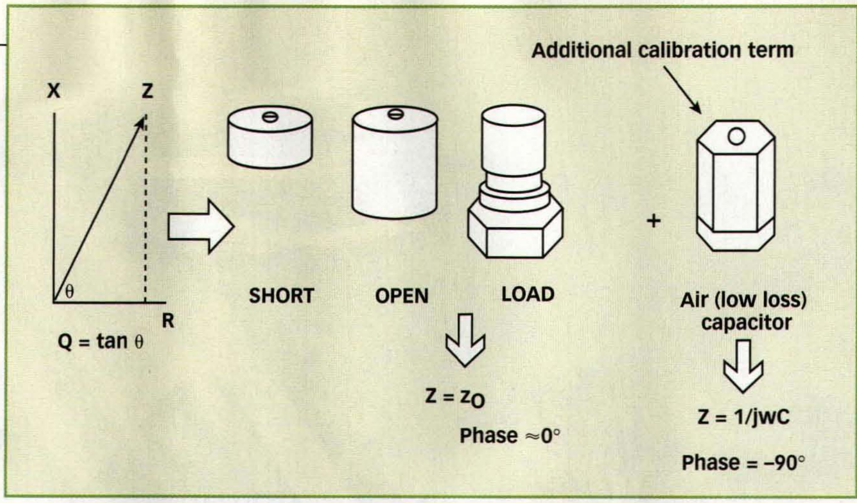
3. The RF-IV technique is yet another method for measuring capacitor and inductor ESR at high frequencies (beyond about 100 MHz).



4. Ten-percent measurement accuracy range from the RF-IV approach (solid line) and the vector-network-analyzer method (dotted line) are compared here.

cess used for calibration. In the autobalancing bridge technique, the process and stability of the instrument is very high, and calibration is performed at a calibration lab once a year.

High-frequency techniques require the user to establish the calibration plane with traceable standards or working standards (i.e., devices in which the user has a high degree of confidence). Since low-ESR devices typically have relatively high Q (although a rectangular metal block may have low ESR and low Q), most measurements are made on devices with low ESR and high Q. While high-frequency techniques also usually employ open/short/load calibration, using only these standards will result in significant ESR error because the phase of these standards is not well known. Because of this limitation, impedance analyzers and impedance-capacitance-resistance (LCR) meters using the RF-IV technique support an additional calibration standard called the low-loss capacitor. This additional calibration device provides a well-known phase reference to the calibration process, which produces much more accurate ESR measurements **(Fig. 5)**.



5. Using an additional calibration device can improve high-frequency ESR measurement.

A typical fixture model **(Fig. 6)** is used for both low-frequency and high-frequency measurement situations, but as frequency decreases, port extension phase shift becomes insignificant. In general, a 1-m port extension can be ignored at frequencies below 100 kHz, and a 10-cm extension can be ignored below 1 MHz.

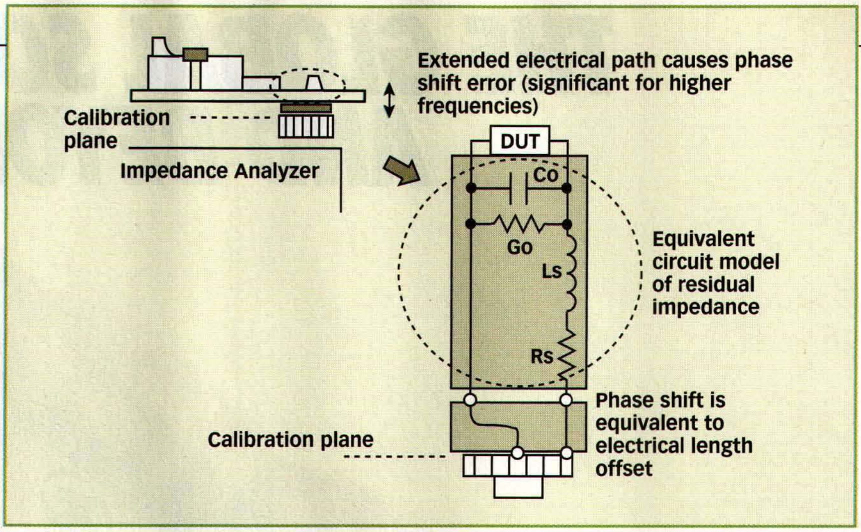
The first step is to remove the fixture errors, excluding the port extension (phase shift). The fixture model includes a series resistor and inductor and a shunting resistor and capacitor. The

open/short compensation process requires that if the value of each of the four elements can be determined and the combination of the DUT with these elements (i.e., the DUT in the fixture) can be measured, the actual value of the DUT can be determined by mathematically removing the effect of the elements. This is theoretically very straightforward but presents some challenges in practice.

To measure the shunting C (B) and R (G) values, open compensation is performed. This simply requires the component to be removed and the contacts to be left in the same position as they would be with the component inserted. The short compensation method is used to measure the series inductance and resistance values. In this case, the DUT measurement contacts must be shorted, which is difficult because while only the fixture's series R and L should be measured, the short will also have a series resistance and inductance. In low-frequency cases, it may be possible to move the contacts to perform a better short compensation, but in high-frequency cases moving the contacts will cause very large errors. Shorting block inductance is also extremely critical at higher frequencies.

A recent improvement has been made in modern impedance measuring equipment that allows the user to enter non-zero short values (for the L and R of the shorting block). This allows all subsequent measurements to be made properly without the need for additional calculations. If the user's measuring equipment does not have this feature, the data can be corrected on a personal computer.

The potential phase error inherent in the model of Fig. 6 (caused by a significant port extension) can be corrected depending on the type of extension, type of measuring equipment, and measurement frequency. Phase shift even causes errors at relatively low frequencies. ESR measurement data has been taken on both a low-frequency impedance analyzer and an RF impedance analyzer. Measurements were made of a 0.01-µF ceramic capacitor on a model 4294A



6. This test fixture model is typically used for both low-frequency and high-frequency measurements.

impedance analyzer from Agilent Technologies (Santa Rosa, CA) with and without a 30-cm port extension. At 1 MHz, the correct ESR value was 390 mΩ, and with the 30-cm port extension it showed 360 mΩ (about 10-percent error). At 10 MHz, the error increased to about 30 percent. An RF impedance analyzer was used to measure the same device, and in this case, the incorrect measurements were performed with about 1 cm of uncorrected port extension.

Another consideration that must be made is how the port extension is to be performed. In the high-frequency case, the complete measuring environment is a single coaxial cable, so any port extension performed after the calibration plane should have minimal loss. Either a delay can be added to the analyzer (typically determined by applying a short and adding the proper delay to return to zero on the Smith chart), or by using a working standard calibration.

In the low-frequency case, other options may exist if using a four-terminal measuring instrument. All of Agilent's autobalancing bridges use the four-terminal pair (4TP) technique that provides superior ESR measurements at higher frequencies. Standard four-wire or five-wire techniques still have mutual coupling (transformer effect) that cannot be eliminated by electrostatic shields. The 4TP system actively drives equal but opposite current in the shield conductors compared to the current flowing in the center conductors. This eliminates the mutual coupling effect that is critical when making low-impedance measurements like ESR.

When making 4TP port extensions, consideration must be given to the degree of coupling and to the measurement frequency. For large devices such as aluminum-can electrolytic capacitors, an attempt should be made to reduce the coupling affect by bringing the current source and voltage sensing leads together at the DUT at right angles to each other.

Fixture contacts play a very important role in the measurement of ESR. All of the discussions of ESR measurement accuracy are related to a perfectly-contacted DUT. In the case of a 4TP system, there are two contacting options. When measuring low-value capacitors (e.g., 10 pF), the total D (ESR) error will be greater with a four-wire contact than with a two-wire contact. Until recently, the four-wire option was used either for very large DUTs measured at low frequencies (usually with alligator clips) or required custom fixtures. The model 16044A fixture from Agilent Technologies brought four-wire contact to SMD devices for the first time. The low ESR values of many of today's capacitors and inductors require that attention be paid to correcting the many sources of error. Fortunately, by understanding the limitations of measurement technique, frequency dependencies, and techniques for fixture-error correction, excellent measurement results can still be obtained. MRF

FOR FURTHER READING

The Effect of Fixturing on ESR Measurements; CARTS Proceedings, 2001.

Bipolar Amplifiers

Standard Options:

- *Connector Options: SMA, BNC, Type N*
- *Integrated Limiters*
- *Input Bias Tee for Fiber Optic Photodetectors*

OPERATING FREQUENCY (MHz)	MODEL NUMBER	GAIN (dB, Min.)	GAIN FLATNESS (±dB, Max.)	VSWR IN/OUT	NOISE FIGURE (dB, Max.) NF_1	NF_0	NF_2	OUTPUT POWER (dBm, Min.)
0.001 – 500	AU-1534	30	0.5	2.0:1	1.3	1.4	1.5	+8
0.01 – 200	AU-1442	35	0.5	2.0:1	1.2	1.2	1.2	+5
0.01 – 200	AU-1447	56	0.5	2.0:1	1.2	1.2	1.2	+12
0.01 – 250	AU-1559	11	0.5	2.0:1	4.2	4.2	4.2	+16
0.01 – 400	AU-1565	54	0.75	2.0:1	1.2	1.2	1.3	+14
0.01 – 500	AU-1310	30	0.5	2.0:1	1.3	1.4	1.5	+8
0.01 – 1000	AU-1402	18	1.0	2.0:1	6.0	5.0	5.0	+16
0.01 – 1000	AM-1300	27	0.75	2.0:1	1.4	1.6	1.8	+8
0.01 – 1000	AM-1431	35	0.75	2.0:1	1.4	1.6	1.8	+8
0.1 – 2000	AM-1364	9	1.5	2.0:1	6.0	6.0	6.0	+10
1 – 200	AU-1464	35	0.5	2.0:1	1.2	1.2	1.2	+6
1 – 400	AU-1421	24	0.5	2.0:1	2.4	2.4	3.1	+17
1 – 500	AU-2A-0150	30	0.5	2.0:1	1.3	1.4	1.5	+8
1 – 500	AU-3A-0150	44	0.5	2.0:1	1.3	1.4	1.5	+10
1 – 500	AU-4A-0150	60	0.75	2.0:1	1.3	1.4	1.5	+10
1 – 1000	AM-2A-000110	26	0.75	2.0:1	1.4	1.6	1.8	+6
1 – 1000	AM-3A-000110	35	0.75	2.0:1	1.4	1.6	1.8	+8
5 – 200	AUP-1568	26	0.75	2.0:1	5.0	4.5	4.5	+28
5 – 300	AUP-1495	11	0.75	2.0:1	15	9.0	9.0	+28
5 – 300	AUP-1496	23	0.75	2.0:1	8.0	7.0	7.0	+28
5 – 300	AU-1021	24	0.5	2.0:1	2.7	2.8	2.9	+20
5 – 300	AUP-1479	36	1.0	2.0:1	2.5	2.7	2.9	+28
5 – 1000	AM-1475	36	0.75	2.0:1	1.4	1.6	1.8	+15
5 – 2000	AM-1573	18	1.5	2.0:1	4.0	4.0	4.0	+21
5 – 2000	AM-1590	36	2.5	2.0:1	3.8	3.8	3.8	+20
5 – 2000	AM-1591	48	2.5	2.0:1	3.8	3.8	3.8	+20
100 – 1000	AM-1412	35	0.75	2.0:1	1.4	1.6	1.8	+14
100 – 2500	AM-1585	26	2.0	2.0:1	3.6	3.6	3.6	+20
200 – 2000	AM-1569	20	1.5	2.2:1	4.2	4.3	4.6	+14
1000 – 2000	AM-1477	37	1.0	2.0:1	1.8	2.1	2.4	+15

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Selecting RF chip capacitors for wireless applications

CHIP CAPACITORS ARE LIKE the electronic glue that holds together the most complex wireless circuits. Capacitors store the energy needed for the advanced operations of cellular telephones, Personal Digital Assistants (PDAs), wireless local-area networks (WLANs), and other popular wireless tools. Designers who would like to brush up on their capacitor fundamentals will find some useful information on ceramic and porcelain chip capacitors in the application note, "Selecting RF Chip Capacitors for Wireless Applications," from American Technical Ceramics (Huntington Station, NY).

As the note explains, the most commonly used design categories for the company's capacitors are multilayer capacitors (MLCs) and single-layer capacitors (SLCs). Both types feature high dielectric strengths, optimized electrode patterns, high quality factor (Q), very high stability, and low dissipative losses.

The two-page note details the key performance parameters for comparing capacitors, including effective series resistance (ESR), quality factor (Q), and dissipation factor. The ESR is one of the most essential factors to consider in the design of an RF circuit, since the ESR provides of measure of evaluating the dielectric and metal losses of a capacitor, as well as the manufacturing quality of the device.

Quality factor is a figure of merit that is a measure of a capacitor's ability to store energy in its dielectric material. As a correlation, a capacitor with a low ESR will yield a high Q value. As with the ESR, the Q must be calculated and evaluated at the design frequency of interest.

The dissipation factor (DF), which is also known as the loss tangent, is the reciprocal of Q. It is a measure of how much of the total reactive power presented to a chip capacitor is lost as heat. The dissipation factor is usually expressed as a number, such as 0.05, or as a percentage, such as 5 percent, of the amount of energy lost in a capacitor as heat. Copies of the application note are available free of charge from the company's website.

American Technical Ceramics, One Norden Lane, Huntington Station, NY 11746-2142; (631) 622-4700, FAX: (631) 622-4748, e-mail: Sales@atceramics.com, Internet: www.atceramics.com.

The dissipation factor is a measure of how much of the total reactive power presented to a chip capacitor is lost as heat.

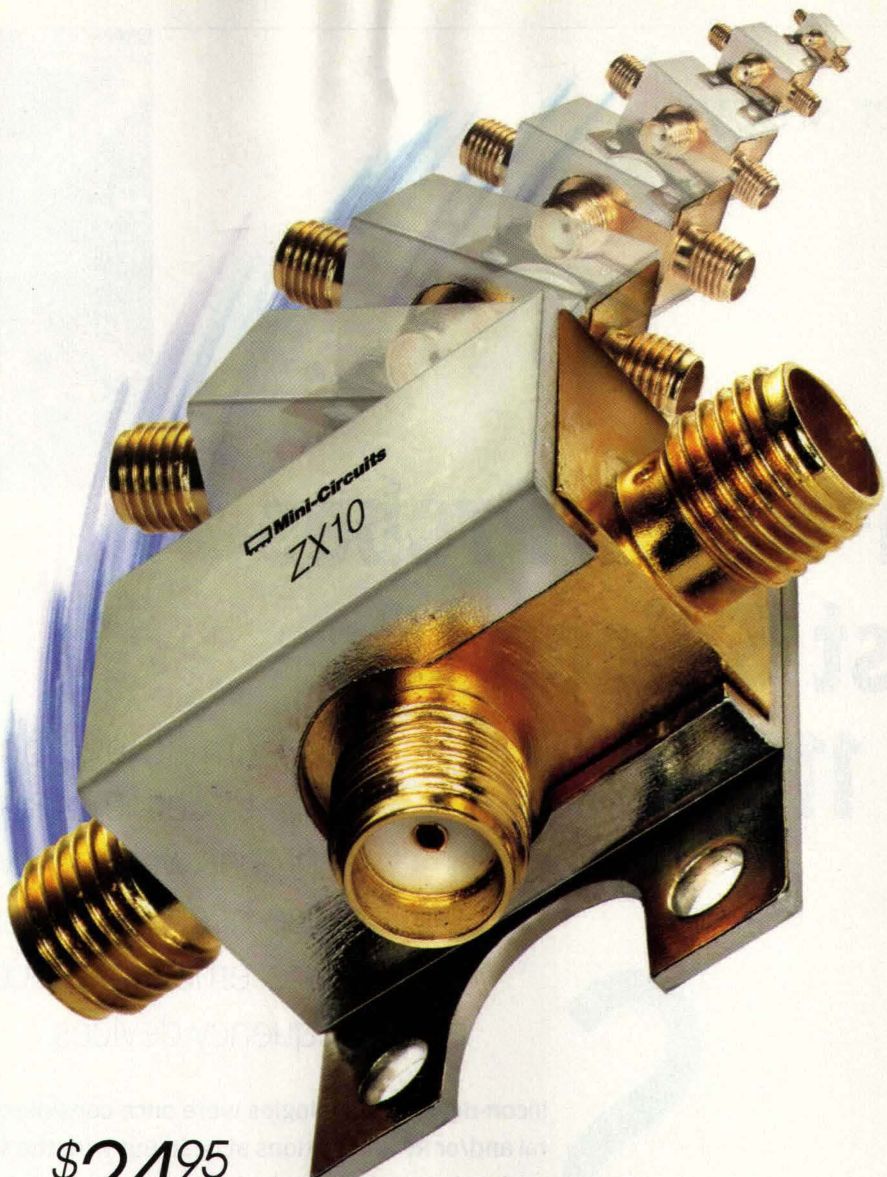
Learn three techniques for measuring short-term stability

MEASURING THE SHORT-TERM frequency stability of a microwave source can be a challenge. Inadequate short-term source frequency stability can be the cause of poor performance and bit errors in microwave systems, so it is important for high-frequency designers to fully understand how to evaluate and analyze the short-term stability of a microwave source. Fortunately, a detailed, 15-page application note from Communication Techniques, Inc. (Whippany, NJ), "Three Techniques for Measuring and Interpreting Short-Term Frequency Stability," offers a solid review of modulation theory along with three approaches to the practical measurement of short-term frequency stability.

The note, which provides chapters on the measurement of residual frequency-modulation (FM) noise, the measurement of phase noise, and how to evaluate phase jitter as a noise parameter, opens with a review of modulation theory in order to establish quantitative relationships between the output spectrum of a signal source and its short-term stability. This review introduces the concept of power spectral density and how it can be applied to the analysis of FM noise and short-term noise in high-frequency oscillators.

The note explains how to convert the power spectral density characteristics of source to the root-mean-square (RMS) signal (voltage or current) level, and then to an equivalent per Hertz value for analysis. The note offers a test setup for making residual FM measurements, as well as three test setups (reference/heterodyne, correlation, and anti-correlation approaches) for making phase-noise measurements on phase-locked sources. A section on calibration techniques includes a way to check the performance of the phase or frequency discriminator used in the phase-noise measurements, with the help of a signal generator and spectrum analyzer. Copies of the note are available free of charge from the company's website.

Communication Techniques, Inc., 9 Whippany Rd., Whippany, NJ 07981; (973) 884-2580, FAX: (973) 887-6245, Internet: www..cti-inc.com.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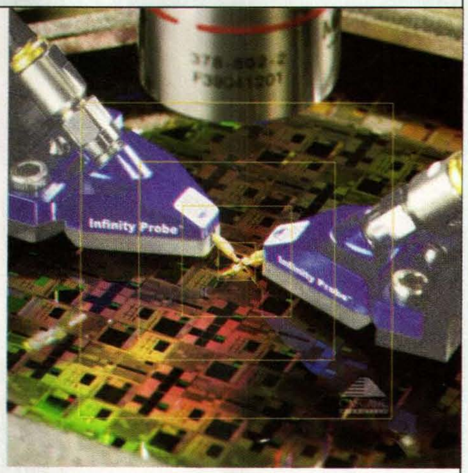


On-Wafer Probes Test Silicon ICs To 110 GHz

Thin-film lithographic technology helps to define the precise features of probes with the low contact resistance needed to accurately characterize emerging silicon-based high-frequency devices.

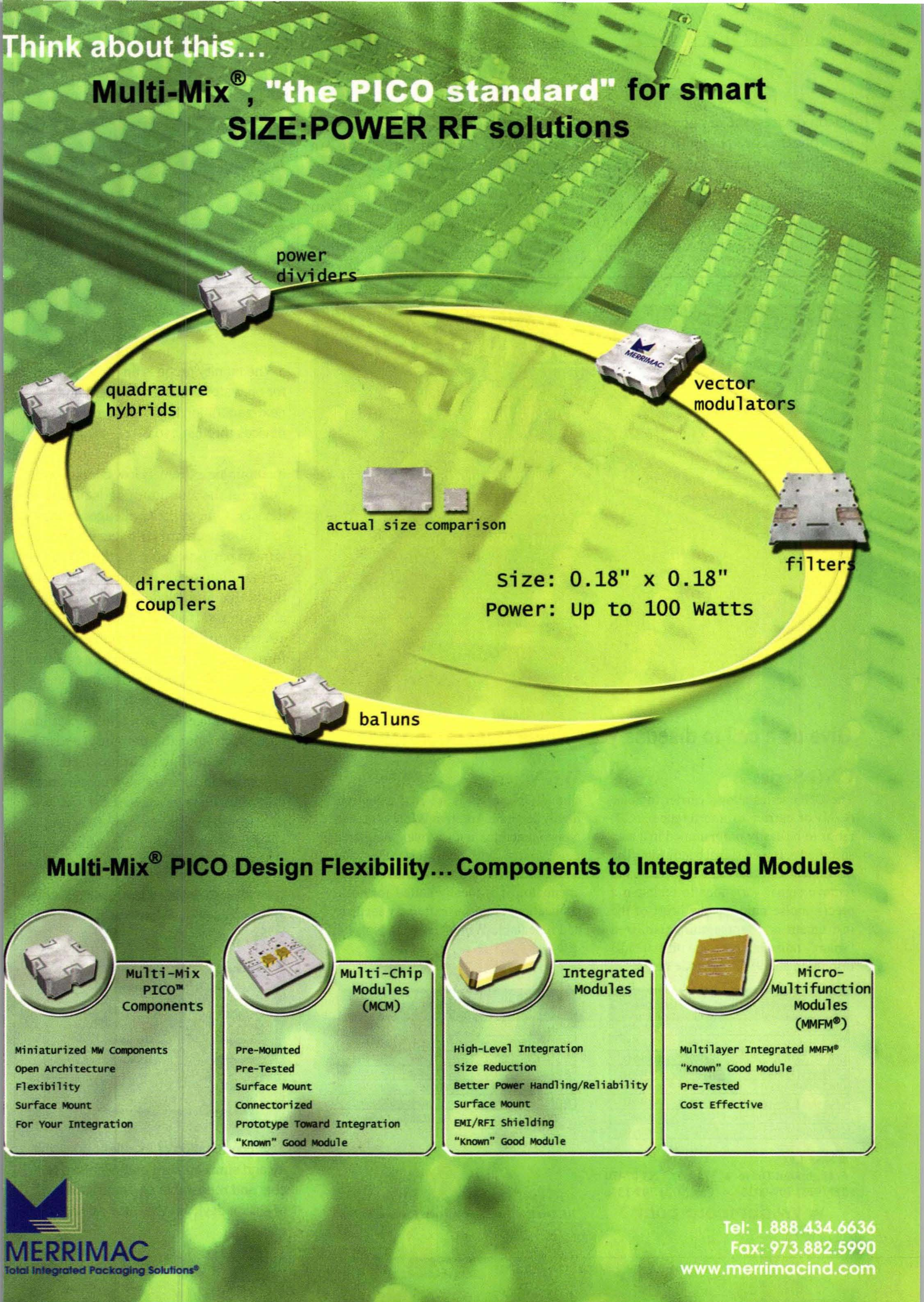
JACK BROWNE
Publisher/Editor

Silicon-device technologies were once considered appropriate for digital and/or RF applications at best. But with the steady development of such advanced technologies as silicon complementary metal-oxide semiconductor (CMOS) and silicon-germanium (SiGe) bipolar CMOS (BiCMOS), millimeter-wave silicon devices are becoming a reality.

Testing such high-frequency, high-speed devices offers a serious challenge to suppliers of on-wafer probes, a challenge that has been taken up by Cascade Microtech (Beaverton, OR) with the introduction of their Infinity Probes™. The new technology enables low and stable probe contact resistance while supporting on-wafer measurements on silicon devices through 110 GHz.

Although silicon CMOS and SiGe devices for millimeter-wave *operation* are not common, an essential part of characterizing and modeling such devices involves the extraction of transition frequencies (f_T's). Since the International Technology Roadmap for Semiconductors (ITRS) projects the f_T of analog CMOS devices to increase from a current high of 150 GHz to a frequency of 370 GHz by 2007, with a similar track for SiGe, there is a strong need for a probe technology that can accurately measure on-wafer signals without degrading the electrical quality of those signals.

A wafer probe, of course, provides the critical signal path between a device under test (DUT) and the measurement equipment, typically a vector network analyzer (VNA). To improve measurement integrity when testing



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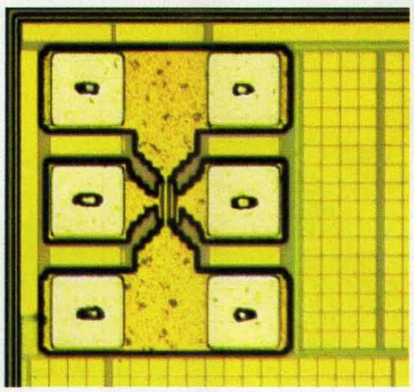
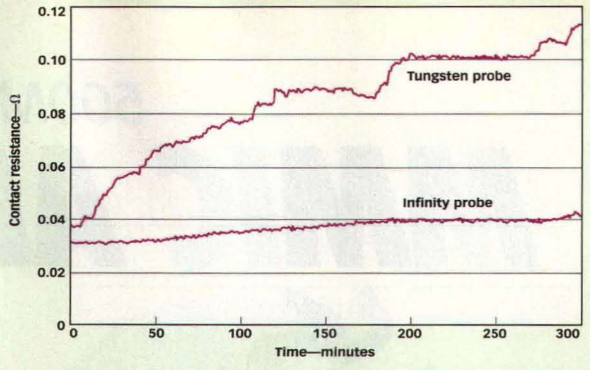
silicon devices, the design of the Infinity probes has been optimized for probing aluminum pads. This is the most commonly used metalization for silicon process wafers, in contrast to the gold metalization usually found on III-V semiconductor devices, such as gallium arsenide (GaAs). In a silicon process, gold (Au) is a contaminant that can cause deep level traps in a CMOS process, for example.

The Infinity probes **(Fig. 1)** benefit from a new technology that delivers excellent high-frequency performance while maintaining extremely low contact resistance on the aluminum pads of silicon devices. One of the challenges in making good electrical contacts on an aluminum pad is penetrating the thin layer of aluminum oxide (about 60 Anstroms thick) that immediately forms on a bare aluminum surface when it is exposed to air. Unfortunately, aluminum oxide will form on any aluminum surface exposed by probing, making it difficult to maintain good and consistent electrical contact resistance for any length of time without cleaning the aluminum and aluminum oxide that accumulates on the probe tips. In addition, any measurement that is sensitive to series resistance will be affected by variations in the contact resistance. This includes measurements of high-quality-factor (high-Q) passive

1. The Infinity probe is an ideal solution for on-wafer probing of current and next-generation high-frequency silicon devices through 110 GHz.



2. A combination of excellent tip visibility and small contact marks enable reliable and repeatable on-wafer probing of silicon devices with 50 × 50-µm pads.



3. The improved repeatability of the Infinity probe is apparent from this comparison with a conventional tungsten probe on aluminum-device pads.

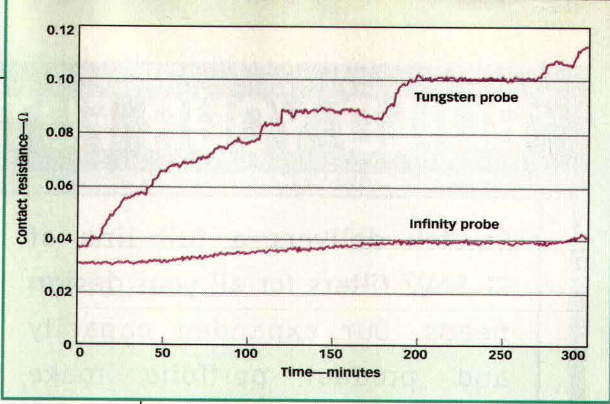
devices and tests that require long duration (more than a few minutes each).

Conventional RF coaxial probes use tungsten tips to penetrate the aluminum-oxide barrier. But tungsten also oxidizes, and the aluminum and aluminum oxide accumulate on the probe tips after only a few contacts, increasing the contact resistance and resulting in poor measurement repeatability. The solution requires frequent cleaning of the probe tips, at a cost of measurement integrity and accuracy, as well as a reduction in the lifetime of the probes. Due to this limitation, measurements are often performed manually, using skilled operators to sense when a contact resistance problem has occurred. However, this results in a considerable increase in test time, test cost, and a reduction in productivity.

Often, the probe overtravel is increased as a way of reducing contact resistance, although with limited success. This approach leads to a greater deformation of the aluminum device pads and serious pad damage. The Infinity probes blend thin-film and coaxial probe technologies to achieve new levels of performance for testing devices with aluminum pads. The thin-film technology is used to lithographically define the microwave interconnections and probe tips on a multilayer polyimide membrane. The thin film consists of two layers. The first layer is a metal ground-plane layer. The second layer routes signal conductors. The microstrip-to-coplanar-tip connections are routed by means of photoprocessed via holes. Nonoxidizing nickel-alloy probe tips are plated and connected to different conductor layers by means of the via holes. The fabrication approach ensures a tightly controlled 50-Ω impedance while maintaining excellent signal integrity. This structure also ensures that the electromagnetic (EM) fields are confined within the dielectric material, thereby suppressing microwave-transmission lodes and reducing coupling to adjacent structures.

The Infinity probes feature typical and consistent contact resistance of less than 0.05 Ω. The probe contact area is

about 12 × 12 µm, with clear contact marks to enable probing of devices with miniature 50 × 50-µm aluminum pads **(Fig. 2)**. An innovative force delivery technique requires that only a small horizontal scrubbing movement is needed to break through the typical 60-Angstrom aluminum-oxide barrier. The vertical overtravel is about 50 to 75 µm, resulting in a required scrub movement of only about 25 µm. Since these minimal movements pro-

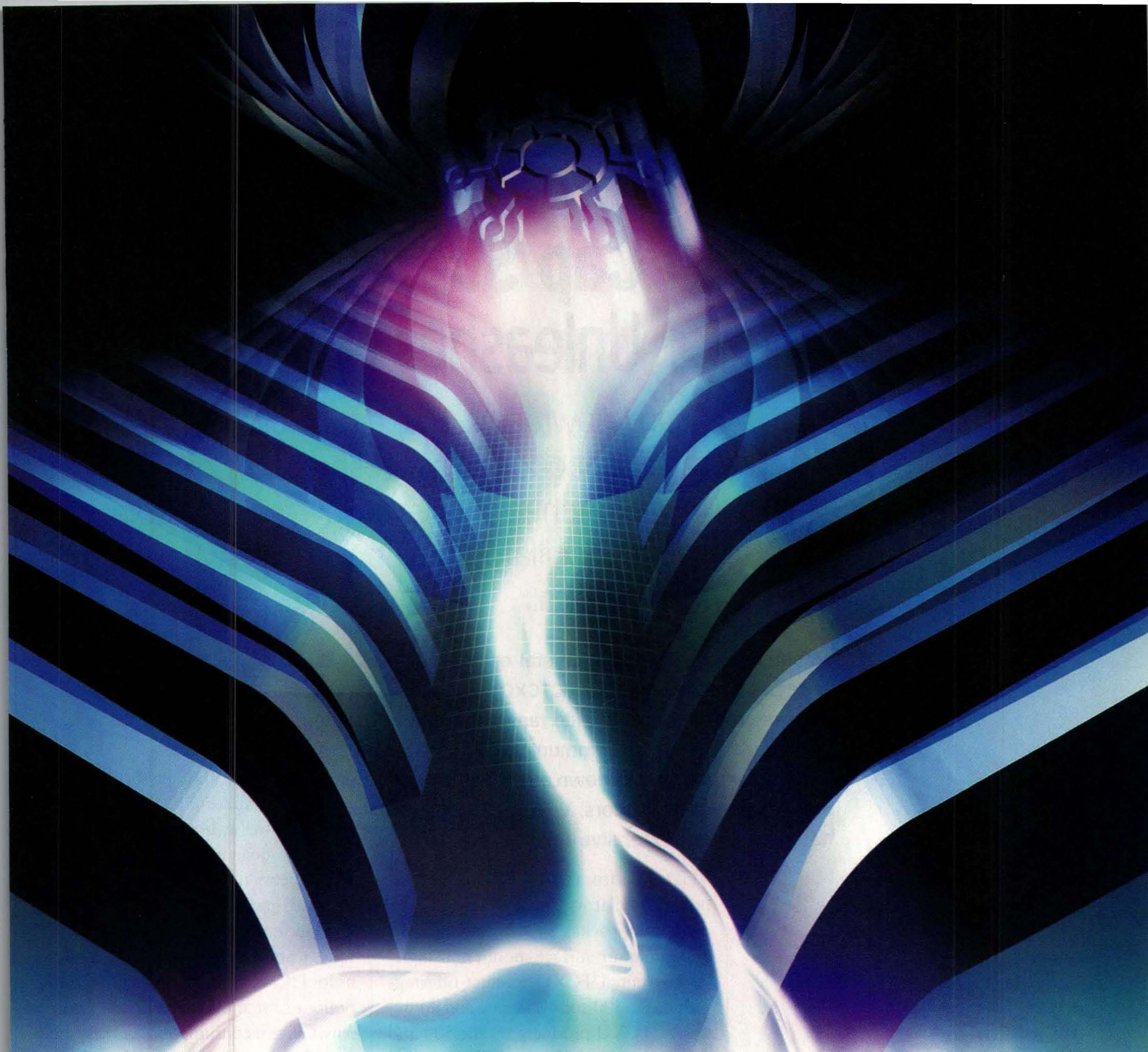


4. Compared to a tungsten probe, only 10-mΩ variations in contact resistance occurred for an Infinity probe during a 5-h continuous contact cycle at 100 mA.

vide good electrical contacts to aluminum pads, excellent repeatability is possible with negligible pad damage.

Tests performed on the Infinity probes show consistent typical contact resistance of less than 0.05 Ω over 100,000 probing cycles on aluminum pads **(Fig. 3)**. During a five-hour, single-contact test on aluminum pads, the typical contact-resistance variations were less than 10 mΩ **(Fig. 4)**. The measured attenuation is less than 1.5 dB to 110 GHz, with more than 12 dB return loss to 110 GHz.

The Infinity probes offer tremendous benefits in test productivity and measurement accuracy, along with considerable reduction in cost of ownership. The company currently offers the Infinity probe models i40 (DC to 40 GHz), i50 (DC to 50 GHz), i67 (DC to 67 GHz), and i110 (DC to 110 GHz) with coaxial connectors. The probes are available in ground-signal-ground (GSG) and ground-signal/signal-ground (GS/SG) configurations, with pitches of 100, 125, 150, 200, or 250 µm. Calibration is performed with the help of the company's line of impedance standard substrates (ISS) which have been verified for accuracy at millimeter-wave frequencies. In addition, the company offers WinCal software for accurate calibrations to 110 GHz. Although designed for probing semiconductor devices with aluminum pads, the Infinity probes are also suitable for testing gold-metallized devices. **Cascade Microtech, Inc., 2430 NW 206th Ave., Beaverton, OR 97006; (800) 550-3279, (503) 601-1000, FAX: (503) 601-1002, e-mail: sales@cmicro.com, Internet: www.cascademicrotech.com.**



Veteran Cap Supplier Unleashes New TCXOs

Long known as a leading supplier of trimmer capacitors, this respected firm has just launched a line of low-cost, stable crystal oscillators for low-power wireless applications.

JACK BROWNE
Publisher/Editor

Temperature-compensated crystal oscillators (TCXOs) and voltage-controlled TCXOs (VCTCXOs) serve as frequency and time references in a wide range of systems, including in cellular and personal-communications-services (PCS) systems. A company once known as the supplier of tuning elements for these oscillators, Voltronics Corp. (Denville, NJ), has now added extensive lines of low-cost TCXOs and VCTCXOs from 4 to 40 MHz. The low-power oscillators are available in both dual-in-line packages (DIPs) and standard and miniature surface-mount housings.

The initial TCXO product offerings include the 300 and 400 series, and the initial VCTCXO products are the 500 and 600 series. HCMOS or TTL (300 and 500 series) and clipped sinewave output signals (400 and 600 series) are available. Standard output frequencies are 10.0, 12.8, 13.0, 16.384, 16.8, 19.44, 20.0, 20.48, 27.0, and 38.88 MHz, with custom frequencies available from 4 to 40 MHz. All of the oscillators provide mechanical tuning of at least ±3 PPM. In addition, the 500 and 600 series oscillators include electronic frequency control over a minimum range of ±10 PPM. All of the oscillators can be set to an initial accuracy of ±1 PPM at +25°C.

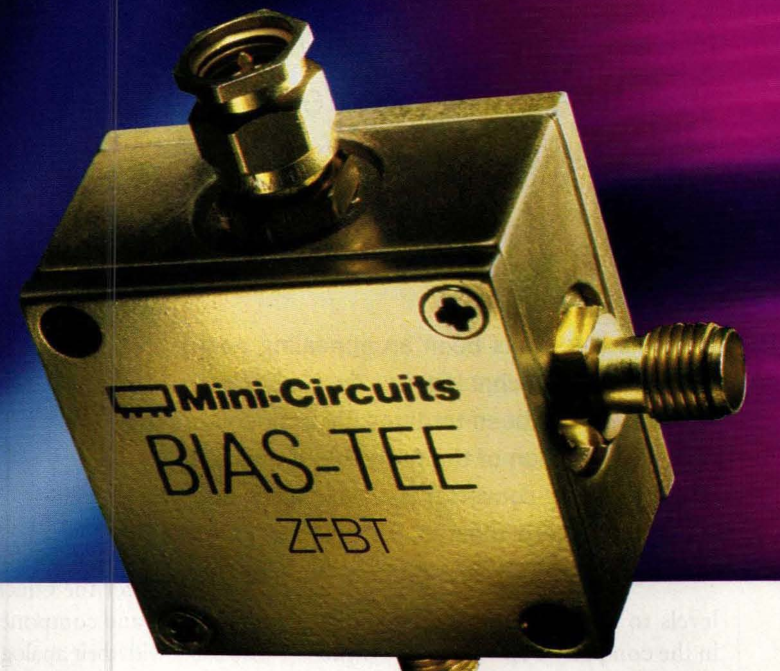
All four source series can be specified for use with +3.3 or +5.0 VDC in standard and miniature SMD packages as well as 14-pin DIP packages. Frequency variations versus supply are better than ±0.2 PPM for all models for a 5-percent change in either supply.

Logic-output models in the 300 and 500 series feature maximum rise/fall time of 4 ns for HCMOS while those with the TTL options have maximum rise/fall times of 3 ns. Current consumption for these models is less than 25 mA. Models in the 400 and 600 series feature clipped sinewave outputs with similar current consumption of 25 mA. All models are offered with a wide range of standard temperature/stability levels **(see table)**, with custom levels available. An aging rate of 1 PPM/yr is standard for all models, as is single-sideband (SSB) phase noise of better than –125 dBc/Hz offset 1 kHz from the carrier.

Voltage-controlled models in the 500 and 600 series offer electronic tuning capability of ±5 PPM for ±2.0 V centered at +2.5 VDC for a +5-VDC supply and ±1.32 V centered at +1.65 VDC for a +3.3-VDC supply. **Voltronics Frequency Control Products, Inc., 100 Ford Rd., Denville, NJ 07834; (973) 586-8585, FAX: (973) 586-3404, e-mail: info@voltronicsfcp.com, Internet: www.voltronicsfcp.com.**

Temperature-stability options

STABILITY LEVEL	TEMPERATURE RANGE	STABILITY
A057	+15 to +35°C	±0.5 PPM
B106	0 to +50°C	±1.0 PPM
C156	0 to 70°C	±1.5 PPM
D206	–20 to +70°C	±2.0 PPM
E256	–30 to +75°C	±2.5 PPM
F406	–40 to +85°C	±4.0 PPM



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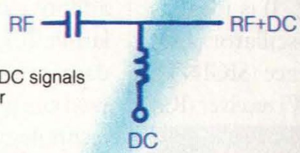

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With Mini-Circuits Bias-Tees, you can DC connect to the RF port of an active device without effecting its RF properties...modulate a laser, apply DC to an amplifier output, and more! Using statistical process control plus combining magnetics and microstrip, large DC currents may pass through the Bias-Tee without saturation and degradation of performance. At 1/3 to 1/4 the price of competitive units, these new Bias-Tees are available in surface mount, pin, and connectorized models. So why wait, solve your connection problems with Mini-Circuits Bias-Tees.

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Model	Freq (MHz)	Insertion Loss (dB Typ.)			Isolation (dB Typ.)			VSWR (Typ.)	Price $ ea
	F_L-F_U	L	M	U	L	M	U	U	1-9 qty.
▲ZFBT-4R2G	10-4200	0.15	0.6	0.6	32	40	50	1.13:1	59.95
▲ZFBT-6G	10-6000	0.15	0.6	1.0	32	40	30	1.13:1	79.95
▲ZFBT-4R2GW	0.1-4200	0.15	0.6	0.6	25	40	50	1.13:1	79.95
▲ZFBT-6GW	0.1-6000	0.15	0.6	1.0	25	40	30	1.13:1	89.95
▲ZFBT-4R2G-FT	10-4200	0.15	0.6	0.6	N/A	N/A	N/A	1.13:1	59.95
▲ZFBT-6G-FT	10-6000	0.15	0.6	1.0	N/A	N/A	N/A	1.13:1	79.95
▲ZFBT-4R2GW-FT	0.1-4200	0.15	0.6	0.6	N/A	N/A	N/A	1.13:1	79.95
▲ZFBT-6GW-FT	0.1-6000	0.15	0.6	1.0	N/A	N/A	N/A	1.13:1	89.95
★ZNBT-60-1W	2.5-6000	0.2	0.6	1.6	75	45	35	1.35:1	82.95
■PBTC-1G	10-1000	0.15	0.3	0.3	27	33	30	1.10:1	25.95
■PBTC-3G	10-3000	0.15	0.3	1.0	27	30	35	1.60:1	35.95
■PBTC-1GW	0.1-1000	0.15	0.3	0.3	25	33	30	1.10:1	35.95
■PBTC-3GW	0.1-3000	0.15	0.3	1.0	25	30	35	1.60:1	46.95
•JEBT-4R2G	10-4200	0.15	0.6	0.6	32	40	40	-	39.95
•JEBT-6G	10-6000	0.15	0.7	1.3	32	40	40	-	59.95
•JEBT-4R2GW	0.1-4200	0.15	0.6	0.6	25	40	40	-	59.95
•JEBT-6GW	0.1-6000	0.15	0.7	1.3	25	40	30	-	69.95

L = Low Range M = Mid Range U = Upper Range

NOTE: Isolation dB applies to DC to (RF) and DC to (RF+DC) ports.
▲SMA Models, FT Models Have Feedthrough Terminal ★Type N, BNC Female at DC
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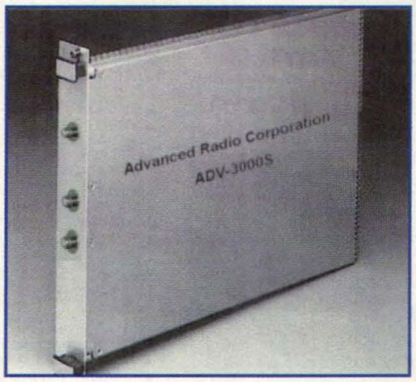
Compact DDS Silences Spurious And Phase Noise

Proprietary circuitry helps this modular DDS to achieve impressive phase-noise and spurious levels from 20 MHz to 3 GHz.

PAUL JACKSON
Chief RF Engineer
SCOTT HARDY
Senior Design Engineer
CHRIS MARTINS
Product Manager
Advanced Radio Corp., 1800 Alexander Bell Dr., Reston, VA, 20190; (703) 435-5900, FAX: (703) 435-1110, e-mail: cmartins@advradio.com, Internet: www.advradio.com.

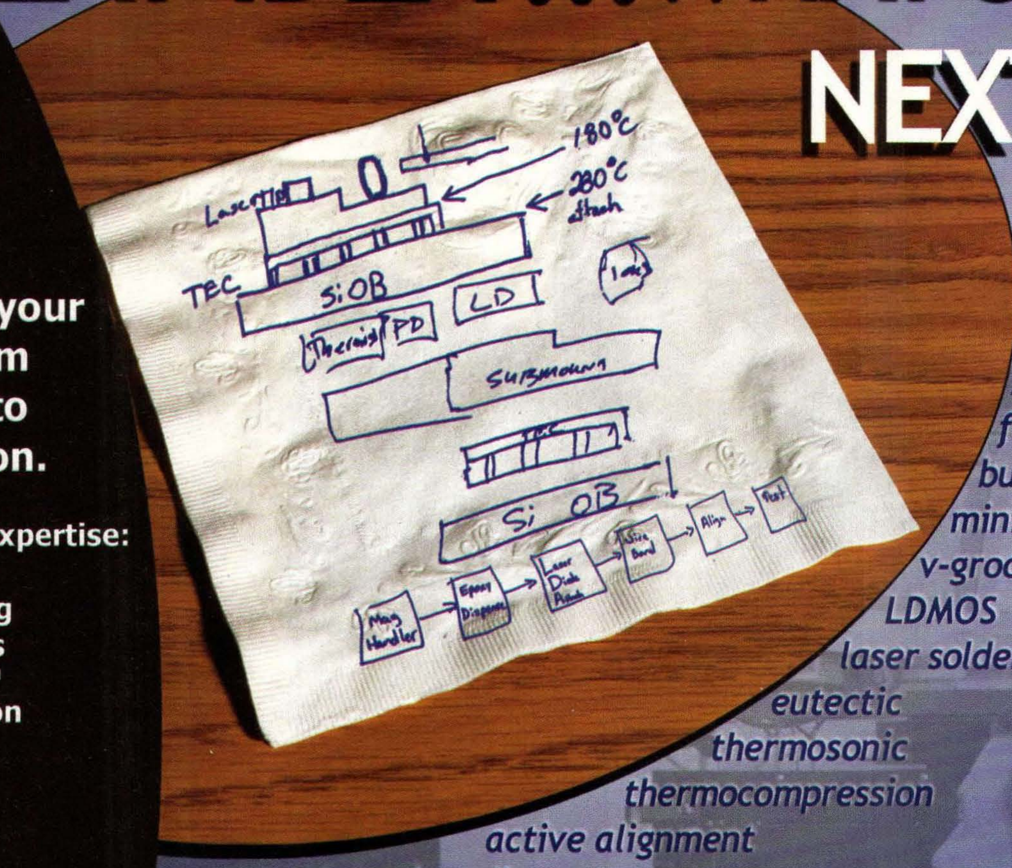
Direct-digital synthesis (DDS) has been an appealing commercial and military source technology for over a decade. One limitation, however, has been traditionally poor spurious performance, as a function of the bit resolution of the DDS and its digital-to-analog-converter (DAC) circuitry. Fortunately, Advanced Radio Corp. (Reston, VA) has developed proprietary circuitry to effectively reduce DDS spurious levels to a bare minimum, embodied in the company's ADV-3000S synthesizer module. The DDS source achieves spurious levels of typically better than –90 dBc from 20 MHz to 3 GHz; the basic architecture can be extended to 18 GHz.

The ADV-3000S **(Fig. 1)** is ideal as a programmable local oscillator (LO) for radar, signal-intelligence (SIGINT), and electronic-warfare (EW) receiver (Rx) applications. The digital circuits used to implement signal-processing functions do not suffer the effects of thermal drift, aging, and component variations associated with their analog counterparts. Commercial applications include base stations, high-data-rate communications links, and test equipment including signal generators and spectrum analyzers. Through programming, the DDS adaptive-channel bandwidths, modulation formats, frequency hopping, and data rates are easily changed. When used as a quadrature synthesizer, the DDS technology affords unparalleled matching and control of in-phase (I) and quadrature (Q) outputs. In its simplest form, a direct digital synthesizer can be implemented from a precision reference clock controlling a numerically controlled oscillator (NCO), a sine look-up table, programmable read-only memory (PROM), and a DAC.

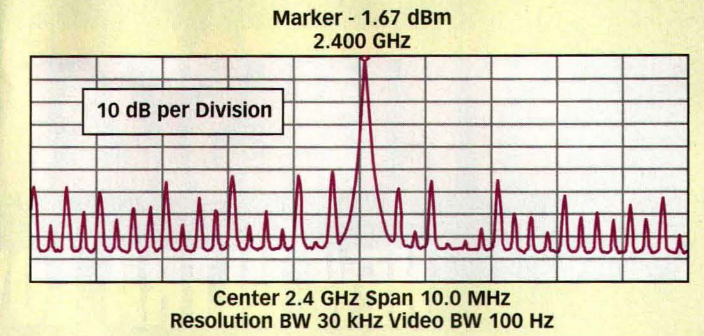


1. The ADV-3000S DDS module incorporates proprietary spurious-canceling circuitry to achieve low noise performance from 20 MHz to 3 GHz.

The ADV-3000S synthesizer operates from 20 MHz to 3.0 GHz with standard tuning resolution of 1 Hz, although its flexible architecture supports a variety of step sizes. It tunes to a new frequency in less than 5 µs, and delivers typical output-power levels of

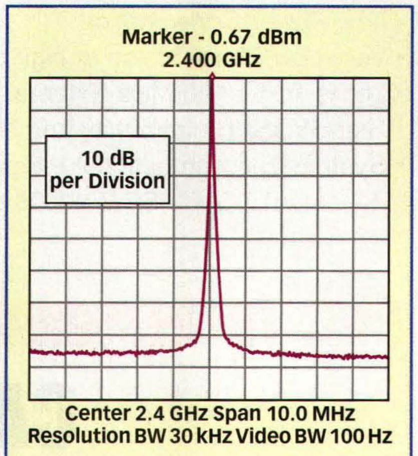


+10 dBm. The measured phase noise is better than –108 dBc/Hz offset 10 Hz from a 104.85-MHz carrier and –142.6 dBc/Hz offset 100 kHz from the same carrier. Verifying such low phase noise required using the 20logN noise multiplication relationship to derive phase-noise levels at lower-frequency carriers from measured results at higher frequencies. The **table** shows the results of the multiplication process. For example, the measured phase noise offset 100 kHz from a 2201.85-MHz carrier is –112.2 dBc/Hz. The 20logN noise degradation of noise as the result of a 21-times multiplication of a 104.85-MHz carrier (to produce 2201.85 MHz) is 26.4 dB. So, to derive the interpolated unmultiplied carrier phase noise floor at 104.85 MHz, this 26.4 dB is subtracted from the measured noise floor of –112.2 dBc/Hz to yield a noise floor of –142.6 dBc/Hz offset 100 kHz from a 104.85-MHz carrier.



2. This plot shows the spurious outputs for an uncompensated DDS source at 2.4 GHz.

The ADV-3000S DDS offers fast frequency agility as well as control of phase hops/modulation and phase-continuous frequency hops with none of the overshoot or undershoot associated with analog phase-locked loops (PLLs). In fact, the synthesizer support a wide range of modulation formats, including quadrature phase-shift keying, (QPSK), quadrature amplitude modulation (QAM), binary phase-shift keying (BPSK), frequency modulation (FM), amplitude modula-



3. The spurious noise is reduced by better than 30 dB through the use of proprietary cancellation techniques.

tion (AM), and linear and nonlinear FM chirp. The system also accommodates frequency-shift-keying (FSK) and binary-phase-shift-keying (BPSK) modulation inputs.

The ADV-3000S features impressive spurious reduction compared to conventional DDS sources. For example, the typical spurious output levels of a 2.4-GHz DDS over a 10-MHz frequency span is –60 dBc **(Fig. 2)**. Using proprietary spurious-canceling circuitry to achieve a better-than 30-dB reduction in output spurious levels compared to conventional DDS sources **(Fig. 3)**.

Interpolated phase noise

OFFSET FROM CARRIER (kHz)	MEASURED PHASE NOISE AT 2201.85 MHz (dBc/Hz)	SUBTRACT 20logN (N = 21) (dB)	EXTRAPOLATED PHASE NOISE AT 104.85 MHz (dBc/Hz)
0.01	–81.4	26.4	–107.8
0.10	–87.4	26.4	–113.8
1	–100.5	26.4	–126.9
10	–111.1	26.4	–137.5
100	–112.2	26.4	–142.6

The ADV-3000S is supplied in a single-slot 6U VME housing measuring 6.5 × 10.3 × 0.8 in. (16.51 × 26.162 × 2.032 cm). It is designed for operating temperatures from 0 to +50°C and consumes less than 17 W of power during normal operation. The standard digital-interface control is through the VMEbus digital interface with optional RS-232 and Ethernet formats. The company has also integrated the ADV-3000S DDS source with the model ADV-3000T very-high-frequency (VHF)/ultra-high-frequency (UHF) downconverter to form a fast-tuning radio solution that operates from 20 MHz to 3 GHz (and can be extended to 18 GHz) with typical noise figure of 10 dB. The input third-order input intercept point is typically +8 dBm, and the output second- and third-order intercept points are +75 and +35 dBm, respectively. The assembly offers standard intermediate frequencies (IFs) of 70 and 140 MHz, with selectable bandwidths of 0.5, 1, 2, 5, 20, and 40 MHz at 70 MHz increasing to 65 MHz at 140 MHz. As with the DDS, the tuning resolution of the downconverter/Rx is 1 Hz with typical phase noise levels of –110 dBc/Hz offset 1 kHz from the carrier, –115 dBc/Hz offset 10 kHz from the carrier, and –125 dBc/Hz offset 100 kHz from the carrier. The typical LO re-radiation levels of –90 dBm. The RF unit is also supplied in a single-slot 6U VME housing. **Advanced Radio Corp., 1763 Fountain Dr., Ste. 101, Reston, VA, 20191; (703) 435-5900, FAX: (703) 435-1110, e-mail: cmartins@advradio.com, Internet: www.advradio.com.**

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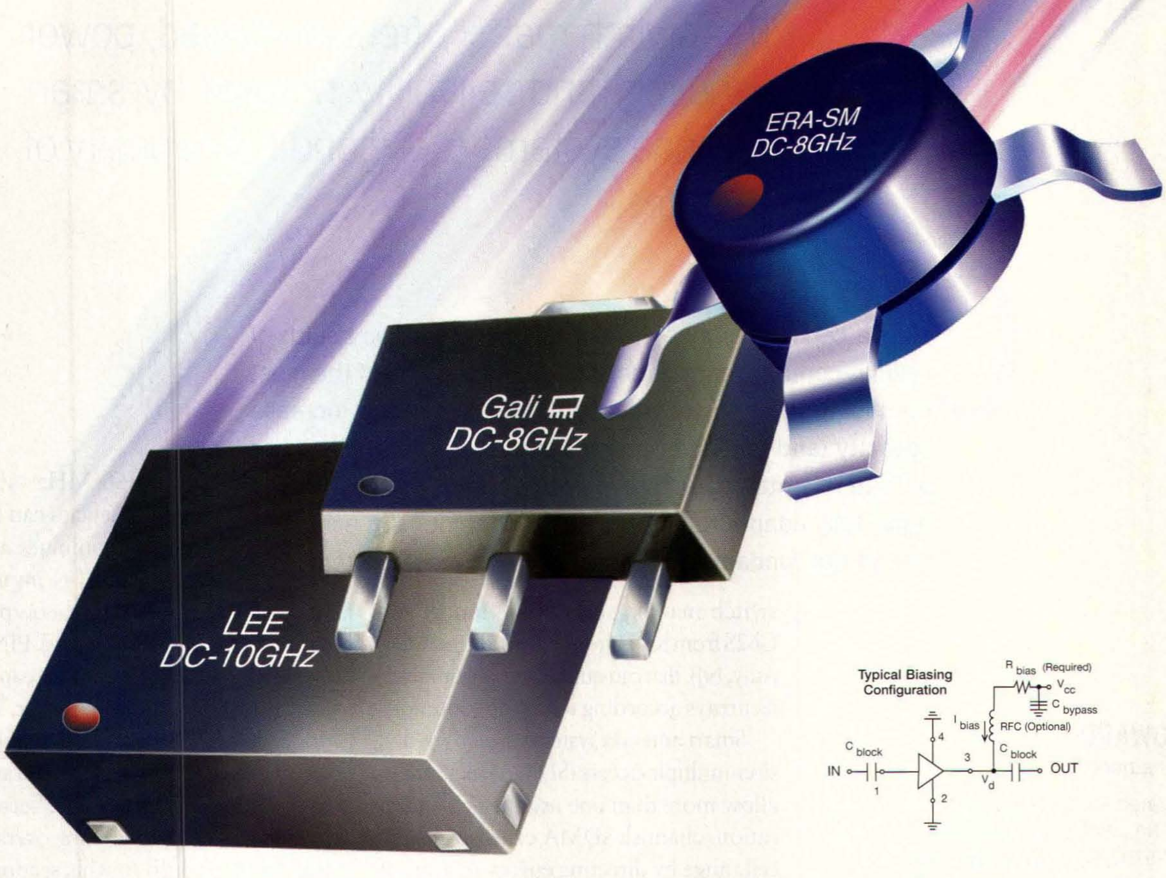

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This switch matrix offers the speed, power handling, and reliability needed by smart antenna systems to expand the capacity of cell sites.

TOM HOWARD
Senior Engineer

KDI Integrated Products, 60 South Jefferson Rd., Whippany, NJ 07981; (973) 887-5700, (973) 887-8100, FAX: (973) 884-0445, e-mail: sales@mcekdi-integrated.com, Internet: www.mcekdi-integrated.com

Cell-site capacity is a key factor for the economic health of cellular-communications service providers. One of the most promising, though technically difficult, ways to increase capacity (and implement new services) is through the use of "smart" antenna technology, which in its most advanced form, fully adapts to current traffic conditions in each cell. One of the fundamental components in these systems is a switch matrix, such as the model AY-G62S from KDI Integrated Products (Whippany, NJ), that can quickly reconfigure antenna arrays according to signal conditions.

Smart antenna systems use space-division-multiple-access (SDMA) methods to allow more than one user per communications channel. SDMA can also increase cell range by directing energy to a specific geographic area. To support these systems, a switch matrix like the AY-G62S must perform well under all temperature and environmental conditions.

The AY-G62S is a high-power, nonblocking switch matrix for operation from 925 to 960 MHz (although other frequencies can be specified) that combines any four transmitter (Tx) inputs each up to 50 W with any of eight outputs **(see table)**. The matrix employs PIN diode switches and combiners that can handle the total 200 W of average power. The four 50-W inputs pass through double-junction circulators with isolation of about 80 dB to ensure that no power is reflected back to the Tx, while maintaining overall insertion loss at 0.3 dB for this section of the matrix. The signals are then connected to the four 1P8T switches. The circulators and switches are connected with flexible low-loss microwave cables. Reverse isolation from output to any input is 60 dB.

Directional couplers are included in the matrix to allow monitoring of forward and reflected power at each antenna output. The unit measures 14.57 × 9.80 × 2.13 in. (37.008 × 24.9 × 5.4 cm) and weighs 20 lb. (9 kg). A wide variety of configurations can be provided in wireless bands through 2.6 GHz. **MCE/KDI-Integrated Products, 60 S. Jefferson Rd., Whippany, NJ 07981; (973) 887-5700, FAX: (973) 884-0445, e-mail: sales@mcekdi-integrated.com, Internet: www.mcekdi-integrated.com.**

The AY-G62S at a glance

Frequency range (MHz)	925 to 960*
Maximum input power (dBm)	47
Input/output return loss (dB, min.)	14
RF to bias filtering (dB, min.)	50
Maximum insertion loss (dB)	8.2
Isolation (dB, min.)	
Between any two points	83
Reverse transmit out to transmit in	60
Input to "off" output	30
Transmit to "off" output	30
Intermodulation distortion (dBc, four 50-W inputs)	90

*Other frequency ranges are available.

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Coupling	Model	Freq. (MHz)	Ins. Loss (dB) Midband Typ	Directivity (dB) Midband Typ
9dB	DBTC-9-4	5-1000	1.2	18
10dB	DBTC-10-4-75	5-1000	1.4	20
12dB	DBTC-12-4	5-1000	0.7	21
13dB	DBTC-13-4	5-1000	0.7	18
13dB	DBTC-13-5-75	5-1000	1.0	19
		1000-1500	1.4	17
16dB	DBTC-16-5-75	5-1000	1.0	21
		1000-1500	1.3	19
17dB	DBTC-17-5	50-1000	0.9	20
		1000-1500	1.0	20
		1500-2000	1.1	14
18dB	DBTC-18-4-75	5-1000	0.8	21
20dB	DBTC-20-4	20-1000	0.4	21

Dimensions 0.15" square.

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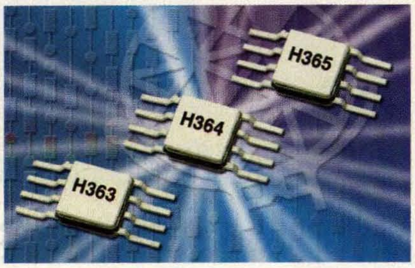

HMC365G8, and HMC363G8 prescalers offer divide ratios of 2, 4, 8 respectively in 8-lead hermetic SMT packages. Both the HMC364G8 and HMC365G8 operate from DC to 13 GHz input frequency while the HMC363G8 operates from DC to 12 GHz. The low additive 100-kHz SSB phase noise ranges from –145 dBc/Hz for the HMC364G8 to –153 dBc/Hz for the HMC363G8. All of these products operate from a single +5-VDC supply. P&A: Sample and production quantities are available.

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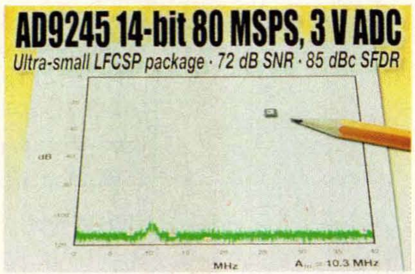

20-/40-/65-MSPS ADC, AD9236 12-b, 80-MSPS ADC, and AD9215 10-b, 65-/80-/105-MSPS ADC. The sample-and-hold amplifier (SHA) can be configured for single-ended or differential operation. P&A: The AD9245 is packaged in a 32-pin CSP and is priced at $38.00 per unit in 1000-piece quantities.

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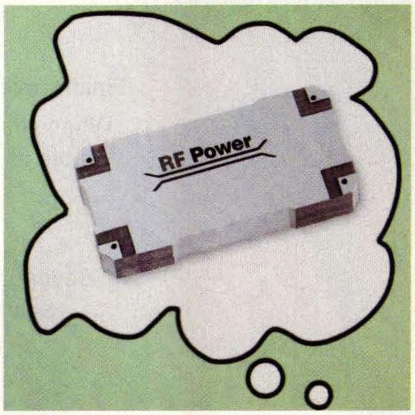

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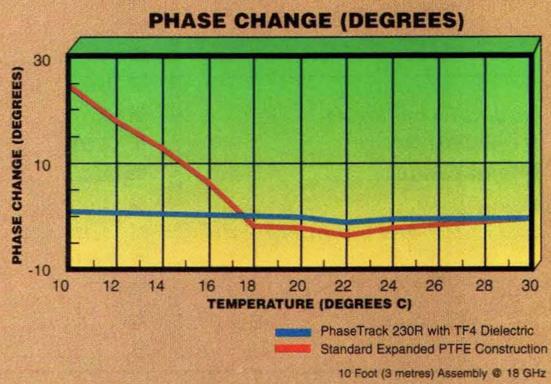

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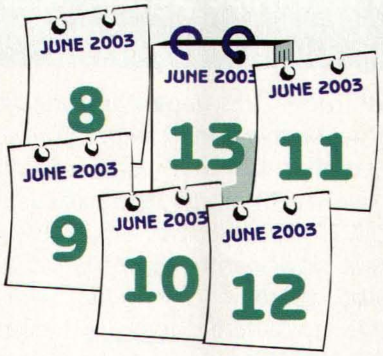

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- *High Power Sources and Control*
- *Low Noise Receivers*
- *Manufacturing, Production and Packaging*
- *Advances in Hybrid Technology*
- *Millimeter and Submillimeter Wave Technology*
- *Monolithic Technology*
- *Active and Quasi-optic Arrays*
- *Lightwave Technology and Techniques*
- *Superconductivity Technology*
- *Microwave Digital Processing*
- *Full Guest Program — Bring the Family!*

In addition to the outstanding Symposium, visit the World's Largest Microwave Exhibition, featuring more than 400 industry innovators displaying their newest wireless and commercial products and services. Once again this year, industry representatives will be presenting application and marketing seminars which will be open to all attendees.

For information on attending the 2003 IEEE MTT-S International Microwave Symposium, please visit the official show website: www.ims2003.org. Or you may send your postal mailing address to *Microwave Journal* via e-mail, fax or postal mail.

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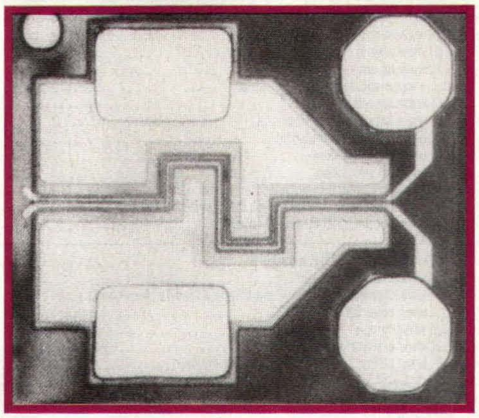
looking back



JUST OVER 19 YEARS AGO, Motorola's Semiconductor Products Sector ventured into the world of GaAs transistors with the short-lived model MRF966 dual-gate GaAs FET.

next month

Microwaves & RF May Editorial Preview

Issue Theme: MTT-S Preview/ Radar & Antennas

News

One of the microwave industry's major events, the IEEE Microwave Theory & Techniques (MTT-S) is scheduled for June 8-13, 2003 in the Philadelphia Convention Center (Philadelphia, PA). Before deciding to make the trip, however, don't miss the industry's most concise and insightful preview of this year's MTT-S, with highlights of the regular technical sessions, panel sessions, workshops, and the RF Integrated Circuit (RFIC) Symposium technical sessions. In addition, this special preview section will also take note of the MTT-S exhibitors and a sampling of key product introductions scheduled for the MTT-S. Get a glimpse at the show in the May issue of *Microwaves & RF*.

Design Features

May's Design Feature section will cover numerous techniques that may prove useful in the design and analysis of both radar and communications systems. Authors from Atmel, for example, will explore what happens to a high-speed digital pulse when traveling along a length of coaxial cable. In addition, authors from Keithley Instruments will offer guidelines for configuring an optimal RF/microwave switching system, while an author from Anritsu Co. will show how to apply complex burst signals to measurements performed on single-carrier and multicarrier power amplifiers for cellular base stations.

Product Technology

In May, the Product Technology section will highlight a pair of chips that team to handle all three major wireless-local-area-network (WLAN) standards: IEEE 802.11a, b, and g. Not only does this chip set provide ease of installation for next-generation WLAN product designers, but it does so with superb RF and baseband performance at a fraction of the power consumption of competing solutions. Additional Product Features in May will offer a second look at an innovative analog linearizer that increases power-amplifier efficiency and linearity, a blind-mate connector system with a new approach, a set of millimeter-wave amplifiers based on novel spatial-combining techniques, and a high-performance test set that speeds and simplifies measurements of radar pulse stability.

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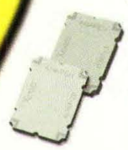
NEW!



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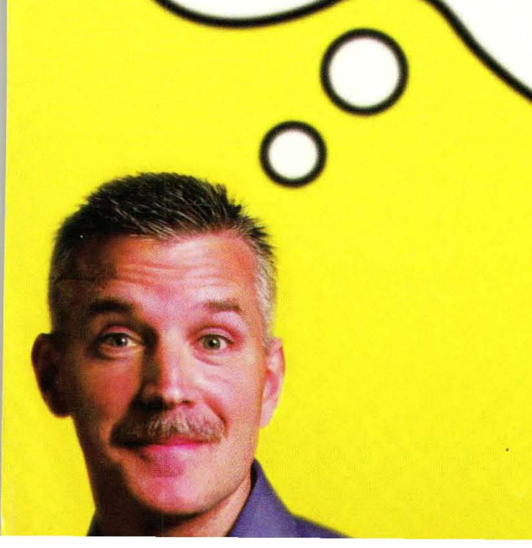

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